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GROUPWARE SYSTEM FOR MULTIDISCIPLINARY PARTICIPATION FINAL REPORT

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MATTHEW C. TRACY
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Quality Decision Management, Inc. (QDM), in our Small Business Innovation Research (SBIR) effort entitled, "Groupware System for Multidisciplinary Participation," has developed a methodology and information architecture that support multidisciplinary participation and communication for a geographically distributed community of individuals and workgroups. The system is an automated environment - based on management methods and workgroup technologies - that improves the effectiveness of workgroup communication and coordination, increases awareness of processes and improves the efficiency of their execution, and provides users with feedback and status metrics. Through this research, we have demonstrated and utilized the synergy between workgroup technologies and management theories. Our work has resulted in a custom software solution for our pilot environment and in a widely applicable system that has been commercialized by QDM and is now available worldwide. The organization-wide benefits made possible by this system have been realized by our clients in both the public and private sectors. Thanks to the research made possible by this SBIR grant, these benefits can now be provided to additional Government agencies and corporate clients at a relatively minimal additional cost.

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PREFACE

This report details the story of a Small Business Innovation Research (SBIR) effort that epitomizes the very purpose and intended results of the SBIR Program, which was established by Congress under the Small Business Innovation Development Act of 1982 and reauthorized under the Small Business Research and Development Enhancement Act of 1992. As a direct result of SBIR funds provided for this effort, Quality Decision Management, Inc. (QDM) successfully developed important, innovative technology in an emerging, exciting new market and was successful in commercializing the resulting technology for sale to businesses worldwide. In effect, QDM conducted and subsidized a Phase III effort in parallel with the Air Force-sponsored Phase II effort to produce **Quality *At Work***, the first workflow-enabled software application for the groupware market.

Needless to say, a successful effort such as this one would not be possible without the strong commitment, active support, and insightful vision of our project sponsors and technology partners. This fact is particularly true in our case, as our effort began at the earliest stage of a totally new market. In addition to facing the expected technological challenges, we found ourselves in continual debate with pragmatists and skeptics waiting on the sidelines to see if this so-called new market was going to materialize and gain popular acceptance. As a result, we are especially grateful to the partners who believed in our efforts and helped to make them so successful.

QDM would like to acknowledge Matthew C. Tracy, our Project Engineer who served as a constant supporter throughout the entire effort. We would also like to acknowledge the series of Technical Monitors - Major Louis Szabo, Capt. Douglas Armstrong, JoLynn Anderson, and Lt. Timothy Townsend - who believed in our work and helped to make sure the technology was used.

Other technology partners who are helping to build the emerging group computing market have been extremely supportive of this effort. QDM is particularly indebted to Lotus Development Corporation and Action Technologies, Inc. for their recognition of our ideas and their contribution of outstanding technology components that have made this effort possible.

There are two people without whom this effort would not be possible. The first is Col. Joseph N. Kruppa, who understood the breakthrough opportunities of QDM's proposed technology and made sure we were able to march forward. Finally most important is Col. (Ret.) Robert Rissell, the "founder" and first director of the FACTS Office, a true visionary who believed in the ideas of a couple of young, excited entrepreneurs.

GROUPWARE SYSTEM FOR MULTIDISCIPLINARY PARTICIPATION FINAL REPORT

SUMMARY

Quality Decision Management, Inc. (QDM), in our Small Business Innovation Research (SBIR) effort entitled "*Groupware System for Multidisciplinary Participation,*" set out to develop a methodology and information architecture that supports multidisciplinary participation and communication for a geographically distributed community of individuals and workgroups. The goal for the system was to create an automated environment — based on management methods and workgroup technologies — that would improve the effectiveness of workgroup communication and coordination, increase awareness of processes and improve the efficiency of their execution, and provide users with feedback and status metrics.

Through the course of this effort, QDM has defined for the first time the discipline of Management Technology. We have pioneered efforts in this field, developing innovative technologies that bridge the gap between the theories of management science and the practical concerns of everyday business. Thus, the effort had a dual emphasis: inventing and integrating innovative technologies and implementing proven management methods into these technologies so corporate cultures would embrace both the groupware system and the methodology embedded in it. As a result of this dual emphasis, the conclusions and observations resulting from our three years of research and development have as much to do with cultural and organizational effects as with technical feasibility and software development. From both perspectives, this effort has been an unqualified success.

Measured in terms of the original technological goal, as stated in QDM's Phase II proposal, we have successfully developed a "group-oriented software system . . . to support multidisciplinary participation and collaboration . . . to promote continuous improvement of both products and processes,"(Quality Decision Management, 1991d). The effort has produced software technology which enables groups of people to work together electronically, to visually examine a distributed network of processes to track the work being done, and to execute plans to continually improve the results of the work. As further evidence of the success of this effort, QDM has extended the resulting core technology of the workflow module of the effort to develop and market a successful commercial software product called **Quality *At Work® (QAW)***.

A good deal of the success of this product is attributable to QDM's realizations about the spectrum of workflow technology at the beginning of this effort. The fact that these realizations led to the development and application of ad-hoc workflow tools and the expansion of the workflow spectrum to include all types of processes, from the most structured to the most ad-hoc, also contributed to the success. With our recognition and use of this new type of workflow came the realization of the criticality of successfully matching the type of workflow solution to the organization's culture and processes.

In addition to these technological lessons, we have learned a great deal about teams and the challenge of implementing breakthrough technology in an organization. We believe that our conclusions derived from the organizational impact of the technology are as important as those derived from the technology itself. During the course of this research effort, we clearly observed that simply using breakthrough technology does not guarantee fundamental changes or productivity improvements in the way people work together. Automation can facilitate workgroup productivity, but to fully appreciate the benefits of the technology requires a commitment to change and learning in the organization. In the final analysis, the technology cannot drive the organization but, rather, must meet the needs of the organizational culture.

INTRODUCTION

Purpose of the Effort

Quality Decision Management, Inc. originally submitted a proposal in response to a topic entitled *Concurrent Engineering* (CE) which appeared in Department of Defense (DoD) SBIR Solicitation 90.1 for Fiscal Year 1990 (FY90). The original topic as stated in the AF90-063 solicitation was to "develop information architectures and new applications of decision science methodology within a concurrent engineering environment."

The intent of the topic as described in the solicitation was to exploit the potential benefits of concurrent engineering in two ways.

- Through development of information architectures, tools, and methodologies to provide the data integration and communication required in a CE environment. The goal of these information architectures is to facilitate the sharing of data and allow horizontal and vertical design parameter tradeoffs.

- Through design and new application of decision support tools which will allow teams to examine design attributes such as performance, cost, schedule, supportability, operability, and producibility.

After successfully completing Phase I of this effort, by researching and designing an information architecture that would meet these criteria, QDM, with sponsorship from the Acquisition Logistics Branch of the Armstrong Laboratory Logistics Research Branch (AL/HRGA), was awarded Phase II contract number F41624-92-C-5006.

The purpose of the Phase II effort was to develop, by integrating pieces of proven technology into a value-added product that could be practically and specifically applied, the process-oriented group support system we had designed in Phase I.

At the beginning of this effort nearly four years ago, QDM recognized that trends in information technology and management science were converging on the notion of improving workgroup communication, collaboration, and productivity. New computer hardware and software was

focusing more on the dynamics of integrated workgroups than on the isolated individual desktop. Management theories were addressing the rate and magnitude of change being necessitated by leaner, more agile, more geographically distributed workgroups and organizations. QDM saw the potential benefits of combining these two concepts, using the emerging technologies as a means to implement the theories. The reason behind QDM's Phase II effort was to develop and implement a system that would help organizations realize these benefits.

The Period of Performance for the Phase II effort was June, 1992, through February, 1994. This Final Report details our SBIR Phase II efforts and the technological and methodological findings and conclusions that they produced.

Subject and Scope of the Effort

Based on the initial SBIR solicitation, QDM set out to come up with a software system that would allow for and facilitate the process of CE. CE was a breakthrough that recognized the power of parallel performance of processes across functional disciplines. Cross-functional, multidisciplinary processes had traditionally been performed serially, with bundles of responsibility being passed from department to department as the process progressed.

QDM's goal in this effort was to develop a methodology and information architecture that supports multidisciplinary participation and communication in parallel for a geographically distributed community of individuals and workgroups. The goal for the system was an automated environment, based on management methods and workgroup technologies, that would improve the effectiveness of workgroup communication and coordination, increase awareness of processes and improve the efficiency of their execution, and provide users with feedback and status metrics with which to gauge their performance.

To better understand the subject and scope of this effort, it would be useful to learn some background information about the technology involved, about the theory behind the development of this genre of technology, and some historical background about QDM's Phase I SBIR effort.

Teamwork: A Communication- and Coordination-Intensive Endeavor

Without communication, effective teamwork is impossible. For years, technologies have been emerging to facilitate and improve communication. In a global economy made up of geographically distributed organizations, departments, and business alliances, face-to-face ("same time/same place") communication is increasingly difficult to organize. Such basic technologies as telephones, voice-mail, and fax machines are designed to combat this phenomenon and, indeed, are effective ways of communicating with others across barriers of time or distance.

However, there is more to teamwork than "one-to-one" communication across telephone lines. True collaboration requires multi-disciplinary, "many-to-many" communication such as brainstorming, consensus building, and focus group discussions to effectively coordinate the efforts of cross-functional teams. This coordination is the element that puts the *work* in teamwork.

Telephone conference calls are one way to facilitate this "many-to-many" communication. However, a conference call requires intensive planning. All parties must be available at the same time in order for the call to take place. In today's fast-paced, dynamic business world, gathering people for a conference call can be as difficult as organizing a face-to-face meeting around a conference table! The true breakthrough for effective teamwork would be a means to facilitate this "many-to-many" communication and collaboration without requiring that all parties be gathered together at the same time or in the same place. QDM realized that this was a significant technological opportunity and was awarded an SBIR grant to pursue a breakthrough system that would foster and facilitate "many-to-many," "different time/different place" communication, collaboration, and coordination, as illustrated in Figure 1.

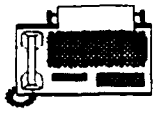
	Same Time and/or Same Place	Different Time and/or Different Place
Communication (One-to-one)		
Coordination (Many-to-many)		

Figure 1
The goal of the workflow-enabled SBIR system is to foster and facilitate "many-to-many", "different time/different place" communication, collaboration, and coordination.

The Evolution of Software Technologies: Groupware and Workflow

Recognizing the criticality of effective communication to the achievement of teamwork in today's distributed business environments, QDM adopted the notion that an effective management strategy must include modification of the communications infrastructure. In most every business today, the communications infrastructure is composed of computer technology. Thus, modifying this infrastructure is fairly simple — one need only take advantage of the technological advances being made in the computer industry.

The software industry has been moving steadily toward providing tools that would enable the "many-to-many," "different time/different place" communications paradigm. In the 1980's, Personal Computers and software packages were focused on increasing the productivity of individual users and the quality of their work. Spreadsheet programs, word processing packages, and presentation software made individual tasks easier. Software has recently emerged that is doing for entire workgroups what the software of the 80's did for individuals. Such group-related tasks as tracking client relationships, processing HelpDesk requests, and managing projects are being automated with tools that are focused on workgroup productivity.

Of course, streamlining the efforts of an entire workgroup is significantly more challenging than checking a memo for spelling mistakes. This new generation of software tools must handle much

more than simple clerical jobs; it must help entire groups work together and coordinate effort. The first step in the coordination process is improved communication. Electronic mail (E-mail) technology met this challenge, providing networked users with the ability to communicate with one another ("one-to-one" communication), or to broadcast information to many others ("one-to-many" communication), even across geographically disparate sites.

The advent of Groupware technology has taken the E-Mail communication concept several steps further; it allows geographically distant users not only to send and receive messages but to share information in bulletin-board style discussion forums ("many-to-many" communication). People are able to profit from the shared information contained in these discussion forums, thus effectively collaborating with their co-workers across the network. As the number of these groupware forums flourish and multiply, it has become increasingly difficult for users to browse, and effectively participate in, all of the available discussions.

Workflow automation helps users manage, organize, and act on the wealth of shared information made available by the groupware environment. It adds coordination to the existing communication and collaboration capabilities of software and has the power to make existing groupware applications more proactive by bringing pertinent information to the attention of the appropriate people and automating and tracking processes to ensure that work gets done. It adds the coordination layer to the "many-to-many" communication capabilities of Groupware, as shown in Figure 2.

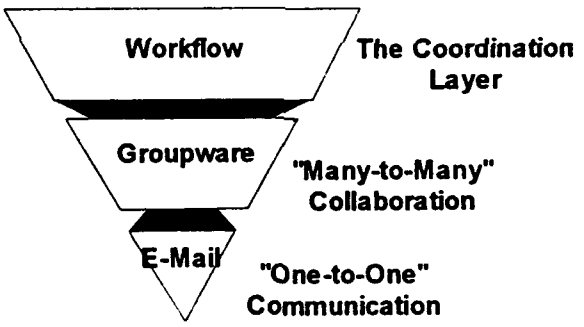


Figure 2
Workflow adds the coordination layer to the "one-to-one" communication of E-mail and to the "many-to-many" communication/collaboration of Groupware

Such technologies as Groupware and workflow are continually being created and refined because people recognize that the greatest barriers to teamwork have often proven to be logistical, organizational, and geographical in nature. Groupware and workflow, as their names suggest, overcome these barriers to teamwork by maximizing the efficiency with which workgroups perform processes and manage the flow of work within and between them.

Groupware and workflow technologies enable the type of multidisciplinary communication and participation that QDM sought for its baseline information architecture. In its Phase II development effort, QDM chose to reap the benefits of a workflow-enabled Groupware platform,

using and enhancing it in order to achieve the desired result of improved, cross-functional teamwork that addresses specified business objectives.

The Evolution of a New Discipline: Defining Management Technology

Just as the advent of Groupware has led to integrated cross-functional teams, the new discipline of Management Technology, a term coined by QDM during the course of this effort, is integrating the once-disparate concepts of software technology and management methodology. Figure 3 shows an illustration of the merging of the two disciplines. Groupware, the software that enabled multidisciplinary teamwork, is itself now integrated with a formerly unrelated discipline. This merging is consistent with the notion, expressed and explained above, that a business' management strategy must be interwoven with its technological and communications infrastructures.

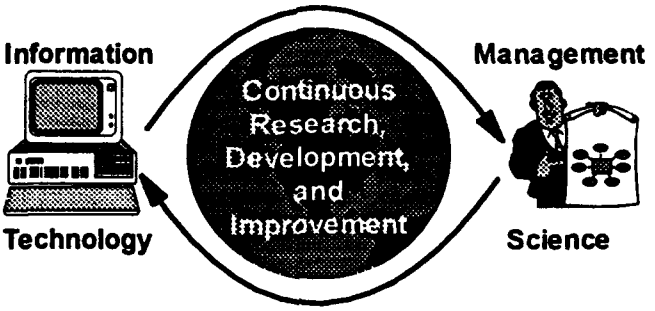


Figure 3
Management Technology is the synergy of two crucial components of business. It enables:
1. Management Methods to Leverage Existing and Emerging Technology
2. Software Technology to Facilitate the Implementation of Management Methods

The combination of software technology with management methodology has proven to be powerful indeed, leveraging the benefits of each concept to create a unified entity that is greater than the sum of its parts. Management Technology bridges the gap between abstract methodological theories and the practical concerns of everyday business. It makes software technology the vehicle that delivers the promised benefits of management methodologies. "Best practices" are embedded in the technology that people use every day, increasing both the functionality of the software and the practicality of the theories it embodies.

The focus of our research and development, then, is on using existing and emerging technologies not simply to automate collaborative processes, but to continue to define, improve, and enhance them.

Historical Background: Quality Decision Management's Phase I Effort

This research effort began almost four years ago when QDM submitted a proposal in response to a topic entitled *Concurrent Engineering,* which appeared in the DoD SBIR Program Solicitation 90.1 for FY90. QDM's proposal title was *Integrating Quality Function Deployment into the*

Concurrent Engineering Environment. The proposed approach was to use a technique called Quality Function Deployment (QFD) as the framework for the system architecture.

QFD was originally proposed as the methodological framework in our Phase I proposal because it represented a comprehensive system that translates customer expectations on functional requirements into specific engineering and quality characteristics. Given the CE origins of the solicitation, it was logical to consider that a QFD system for designing products based on customer requirements, involving all members of the design, development, and support communities, would provide an effective foundation for our efforts. At that time, CE was defined as an integrated process that engineers the product, the manufacturing, and its support processes together with emphasis on efficiency, improved quality, and reduced cost.

A Phase I contract was awarded to QDM effective 23 April 1991. Since this initial award, much has changed. The technologies and ideologies relevant to the effort have steadily matured. The essence of QFD and CE was the process of integrated design, engineering, and manufacturing. Yet the emphasis of our SBIR effort is on the systems and processes that support the *people working* in the framework of a CE process. Consequently, the emphasis of our research and development shifted from the specifics of CE to incorporate the aspects of Total Quality Management (TQM), continuous improvement, and learning organizations which address the behaviors of people in the process, not the mechanics of the process itself.

QDM, in addition to keeping pace with such methodological advances, has had to continue to manage the relationship with our Air Force customer during the time of wholesale changes in the framework of that organization throughout both phases of the effort. QDM has had the challenge of developing and delivering a system that not only makes use of the best currently available tools and techniques but also meets the specific, changing requirements of the Air Force.

Although the Armstrong Laboratories Logistics Research Branch originally submitted the research topic and serves as the contract monitor, an organization called the FACTS office has defined many of the technical requirements and financed the Phase I and Phase II efforts completely. The Fasteners, Actuators, Connectors, Tools, and Subsystems (FACTS) office is the organization that has undergone extensive, iterative reorganizations throughout this effort.

The foundation for the FACTS office was laid in June 1988, when the Air Force chartered a Scientific Advisory Board (SAB) panel to investigate Aircraft Infrastructure-Subsystem and Component Reliability Research and Development Needs. Because of significant improvements made in the preceding decades to aircraft electronics, engines, structures, materials, and software, the seemingly simple subsystems in the mechanical infrastructure had become limiting factors to continued improvements in overall weapon system reliability and maintainability.

The SAB panel concluded that the Air Force spends approximately $2 billion annually on simple structural aircraft parts (screws, nuts, bolts, etc.). Responsibility and management of these parts had been spread throughout the federal government, including the Defense Logistics Agency (DLA), the General Services Administration (GSA), and the DoD. In January 1990, the FACTS office was established to address the SAB findings. FACTS is charged with improving the reliability and maintainability of FACTS parts and with improving the processes in place to acquire and provide the parts to aircraft maintainers.

The original Phase I effort concluded on 23 October 1991. During this phase of research, QDM demonstrated the feasibility of the proposed environment through research and demonstration of stand-alone pieces of existing and emerging technology in the areas of groupware, business process redesign, workflow management, management and planning tools, and graphical user interface environments. Results included:

- design of a methodology that thoroughly supports cross-functional teamwork and collaboration;
- design of a system that can be developed with minimal risk through the integration of proven, existing technology;
- establishment of technology partner relationships with commercial software companies possessing related existing and emerging technology, and with early end-user adopters;
- demonstration and prototype development in groupware and open workgroup computing environment applications using Lotus Notes; and
- demonstration of the feasibility of a graphical database program to link, organize, and display data from different databases.

To maintain continuity in the research effort between Phase I and Phase II, a four month modification to the Phase I effort was made effective 3 February 1992. The modification consisted of three tasks extracted from the initial tasks proposed for the Phase II effort, but the major focus of the Phase I modification effort was research in workflow methodology and technology to create a prototype workflow management system in a groupware environment. We were very successful in that regard, as a workflow-enabled Project application was installed and used by the Business Opportunities Division of the Center of Supportability and Technology Insertion (CSTI). (At the time the initial workflow application was developed, the FACTS office was a part of the CSTI organization.) Detailed information about this system is given in the Workflow Module section of this report, *Phase I Modification: PIBO Production Workflow System*.

Outline of Final Phase II Report

This report summarizes more than three years of a truly innovative research and development effort which has resulted in cutting-edge technology and valuable, practical knowledge. In addition to this introductory section, the report contains the following sections.

Groupware System for Multidisciplinary Participation describes the assumptions, method, and approach used throughout the research effort. Emphasis on the important consideration of cultural phenomena in the design of the software system is explained. The section chronicles the evolutionary development of the groupware system, procedures for the iterative development process, and the application of the technology to a selected test environment.

Discussion of Results presents the results of the research effort. Results are reported with respect to the relative successes of the portions of technology development as well as results from the use and implementation of the technology in the test environment.

Concluding Remarks discusses the outcome of the results with respect to our initial assumptions and the implications of these results for the future. The section enumerates observations made by the research team and explains how these observations can be leveraged to produce the most benefit from the effort.

Recommendations concludes the report with a series of suggested actions specific to the test environment and also to technical and management communities in general. This section describes our strong beliefs about where the groupware market is heading and what approaches will be necessary to derive the most benefit from a powerful new discipline.

GROUPWARE SYSTEM FOR MULTIDISCIPLINARY PARTICIPATION

The Role of Management Technology

Basis of Quality Decision Management's Methodology

Since the origins of this effort began four years ago, we have witnessed substantial changes in the research and theories which have influenced the outcome of this SBIR effort. From an initial emphasis on CE, the process of integrated design, engineering, and manufacturing, the emphasis of our SBIR effort has focused on the systems and processes that support the *people working* in the framework of a CE process.

In fact, the emphasis of our SBIR effort is on the *systems and processes that support people working together toward the achievement of any business objective*. It became increasingly apparent throughout this research effort that certain fundamental activities are common to any organization or group of people working together, regardless of the nature of the work. QDM's methodology is based on the fundamental elements of how people work together and what tools and techniques can facilitate coordinated group activity.

Consequently, the emphasis of our research and development shifted from the specifics of CE to incorporate the aspects of TQM, continuous improvement, and learning organizations that address the behaviors of people in the process, not the mechanics of the process itself. Coordinating requests and actions, soliciting input from colleagues to make effective decisions, building consensus within the group, learning from group experiences and best practices, experimenting with new approaches, all represent skills fundamental to workgroup activity.

The Air Force demonstrated its awareness of this shift during the course of our effort in the evolution of CE into Integrated Product Development (IPD). IPD incorporates the principles of TQM to emphasize the importance of teamwork and continuous process improvement in the design and acquisition of systems. QDM continued to build on this trend throughout the effort.

As the theories involved in CE evolved into IPD and our original emphasis on QFD expanded to encompass TQM, continuous improvement, and organizational learning, QDM devised a set of procedures and techniques that integrate aspects of all these methodologies to help businesses meet and exceed customer requirements. Through organization-wide continuous improvement, businesses are able to consistently satisfy customers and reach corporate goals.

Noted researchers and respected analysts such as Dr. Robert Johansen of the Institute for the Future (IFTF), David and Ronni Marshak of the Patricia Seybold Group, Esther Dyson of EDVenture Holdings, and fellow pioneers in groupware development such as Action Technologies and Lotus Development Corporation have praised QDM's proposed methodology as innovative and highly applicable. These people and companies are pleased by QDM's emphasis on groupware technology as a means to support processes rather than as a means of passing data across networks.

As defined in our methodology, three factors create and sustain an environment of teamwork to deliver customer satisfaction. The three factors, as depicted in Figure 4, are:

- horizontal communication,
- daily management, and
- vertical alignment.

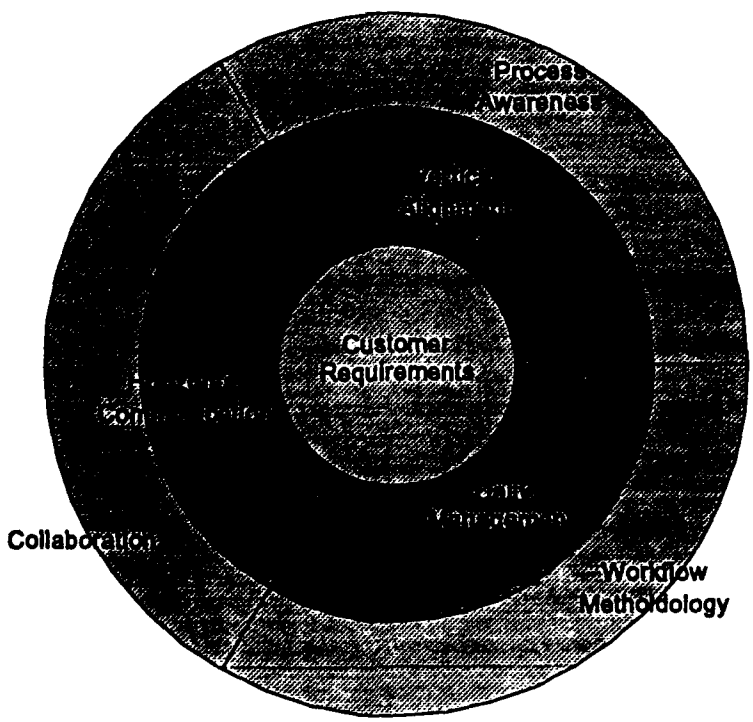


Figure 4
Methodology to Support Multidisciplinary Participation

Horizontal communication concerns the methods by which the functions and departments throughout an organization work together to achieve the mission. To effectively accomplish the organization's mission, cooperation across many different functions and disciplines is required. The emphasis is on effective collaboration, not simply on communication. Horizontal communication requires collectively sharing ideas and information.

Another important factor for a complete team environment is daily management. *Daily management* is characterized by the actions that cascade through an organization to incrementally achieve organizational objectives. Without a way to manage the endless variety of fundamental tasks that collectively bring an organization closer to long range objectives, meaningful progress toward objectives would be impossible. Typically, we refer to these fundamental tasks as work, and we refer to the process of performing these tasks as workflow.

Vertical alignment refers to processes. How does an organization plan strategic objectives and determine its direction? How does an organization create awareness of processes and draw upon the expertise of everyone from the CEO to the assembly line worker to follow strategic direction? To answer these questions is to define processes that represent the organization and provide information about how the organization thinks and works together. A process-orientation provides meaningful perspective for all people in the organization regarding their roles in the process and their contribution to organizational objectives. Vertical alignment can be achieved through modeling organizational processes.

Horizontal communication, daily management, and vertical alignment are the components of our system for multidisciplinary participation. Even independent of software, an environment that sustains effective teamwork will consist of a synergistic blend of these components. The groupware system designed during Phase II of our SBIR effort aims to achieve this synergy and to dramatically improve the effectiveness of these elements both as individual components and as a complete, integrated system.

Mapping Technology to the Methodology

The factors of horizontal communication, daily management, and vertical alignment can each be addressed by pieces of existing technology. QDM's goal for the Phase II SBIR effort was to not only address each factor separately, but to use these software technologies to craft an integrated management system.

The Groupware platform itself is instrumental in addressing the horizontal communication aspect of the methodology. Indeed, the whole idea behind Groupware is enabling exactly the type of information-sharing that is called for in our methodology to support multidisciplinary participation. Groupware platforms such as Lotus Notes® help users from all departments and disciplines contribute their own expertise and profit from that of others. All users have the full complement of information with which to collaborate effectively and to make informed decisions.

A workflow system can be the technological vehicle used by team members to act on these decisions. While workflow can take the form of blind, station-to-station routing of responsibility, QDM believes that a workflow system can and should have a methodological foundation.

Because a workflow system can facilitate the most fundamental aspect of a business' operations, the daily management of assignments and activities, it must be grounded in a solid, proven philosophy. The value that QDM placed on the methodological aspects of workflow, especially as they relate to the daily management of activity, led us to select the Action Technologies, Inc. tools and methods detailed in the *Workflow Module* section.

A process orientation allows a business to examine the activities that are taking place via the workflow system. Examining, analyzing, and modifying processes is critical to the notion of vertical alignment. QDM's plan for the Phase II SBIR effort was to build a Graphical User Interface (GUI) over the workflow module of the system. This tool would read data from the workflow module, then graphically display process-oriented information in colorful, dynamic, easy-to-understand charts and graphs. These displays can be viewed by all appropriate levels of the company to increase process awareness and analysis. A well-designed Graphical User Interface gives everyone a better understanding of organizational processes and each individual's specific role in them.

Quality Decision Management's Critical Assertion: The Human Side of Management Technology

All of the technologies discussed above are readily available. The market for Groupware and workflow systems is exploding. GUI technology has existed for more than a decade and gets smarter and more powerful with each successive release. Each of these technologies is sufficiently sophisticated to perform the functions and provide the benefits described above. As these technologies continue to undergo refinement and widespread proliferation, it becomes more and more clear that the barrier to organization-wide change and continual process improvement is not technological.

In fact, not only are these technologies not barriers to change, they actively enable it: "Groupware and organizational change go best hand in hand" (Opper, 1992). What, then, is preventing organizations and businesses around the world from immediately realizing the benefits of groupware? The answer to this question is the core of QDM's philosophy: Technology Cannot Drive the Organization. Note that in our discussion above, we mapped the technology to our existing methodology, not the reverse. The agents for change and improvement thus remain conceptual, not technological. It is better to model a business after solid concepts of management, communication, and alignment than to force the model into a preexisting technological mold.

Simply stated, QDM's core philosophy is that having individuals and workgroups perform processes as dictated by the parameters and constraints of their hardware and software technology is putting the cart before the horse. Rather, the technology must be responsive to the organization and sensitive to the corporate culture. User needs should drive the design of the information architecture.

However, even a culturally sensitive system is prone to failure if it meets with consistent, unbending user resistance. In using technology to effect change and move toward a "Learning Organization," everyone, from management through support staff, must commit to the effort and

accept the system as an effective change agent. All users must be eager (or at least willing) to use the technology to acquire knowledge about the way they do things. They should be ready to use this knowledge to continually reexamine, reevaluate, and, if necessary, modify their behavior to optimize performance.

Avoiding this resistance in the first place is much easier than overcoming it. Thus, QDM's core assertion about the creation of technology solutions also applies to their implementation. The introduction of new technologies into the user environment should be as culturally seamless as the technologies themselves, gradually building user acceptance from the foundation of an initially positive reaction.

Rapid Prototype Development Process

QDM's approach to software development mimics that of a successful user of a well-designed groupware system. Such users take an iterative approach to continuous improvement. They use the system to capture and analyze their work patterns, repeat those that proved successful, and modify those that could be improved. QDM's Rapid Prototype Development Process was similarly iterative; we would incrementally develop prototypes of systems and continually modify them based on feedback from Air Force users. We would add desired functionality and tailor the system to ensure the system continued to meet the changing needs of our customer.

One of the most important factors in QDM's ability to develop prototype systems rapidly was our ability to leverage and integrate proven, existing technologies rather than attempting to build everything from scratch. The Groupware platform, workflow capabilities, and Process-Oriented Graphical Front End were selected to address the collaboration, coordination, and process awareness aspects that are the cornerstones of QDM's methodology (see Figure 5).

Incremental Development Approach

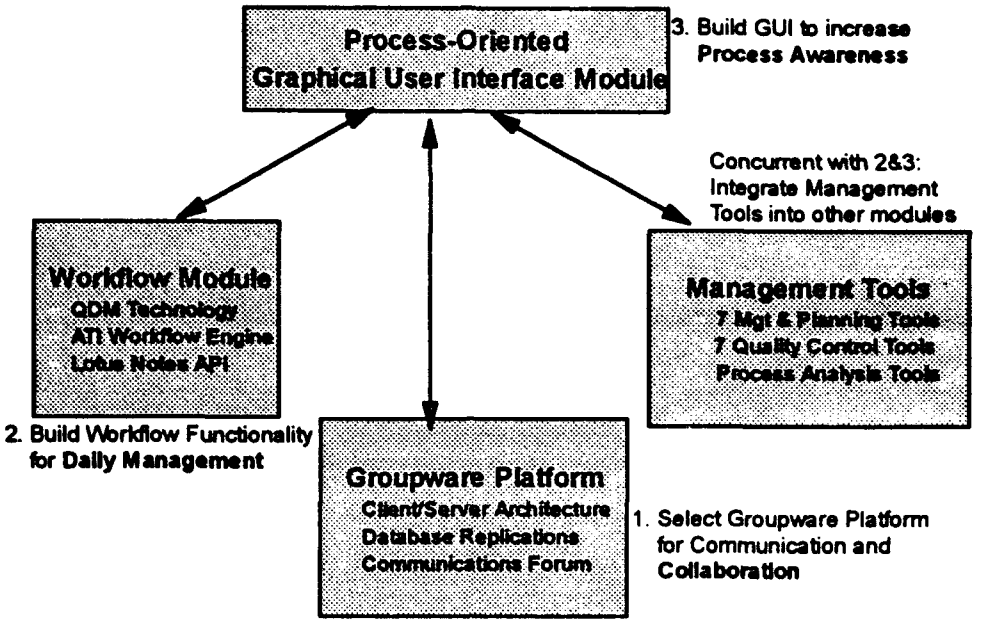


Figure 5
With the Groupware platform as a baseline, functionality consistent with QDM's developed methodology is added to form a fully integrated system

As explained above, each of these individual modules of technology is mapped to a critical factor of our teamwork environment methodology: the collaboration of Groupware to the horizontal communication factor, workflow methodology to the management of daily activity, and GUI-enabled process awareness to vertical alignment. The management tools are fully integrated with the other modules and address all three of the teamwork factors, as shown in Figure 6.

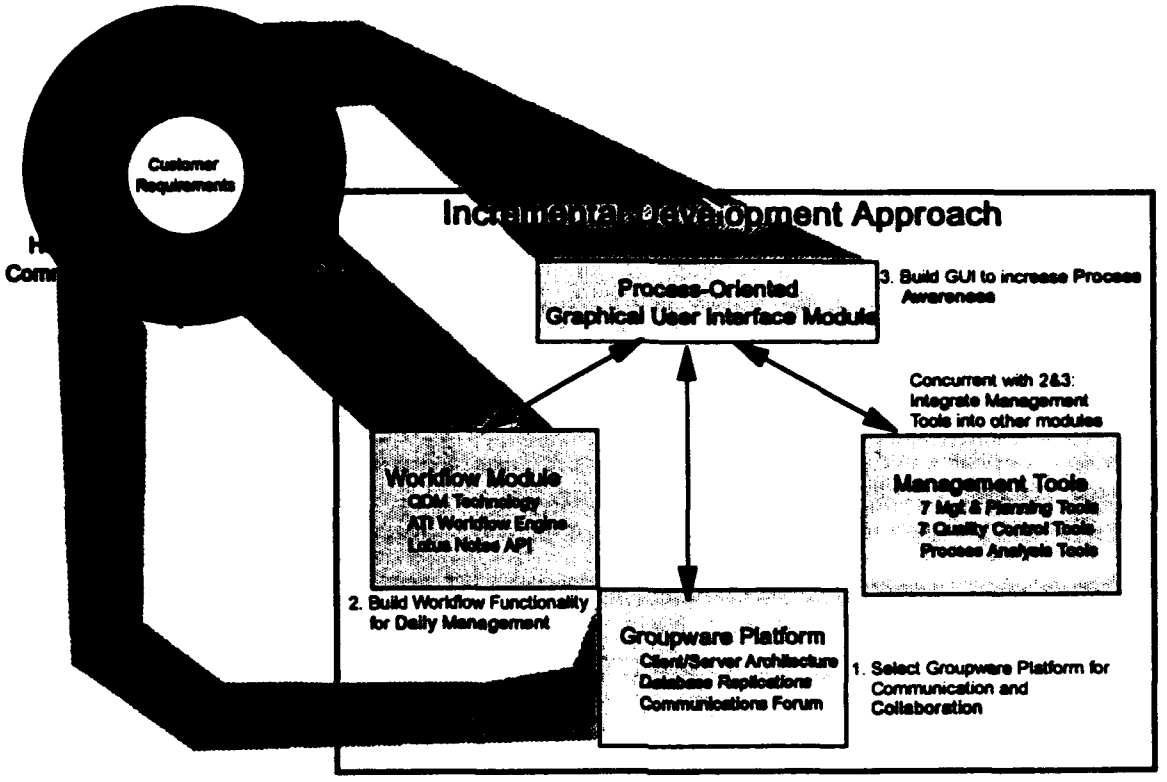


Figure 6
Each module of SBIR technology development is mapped to a teamwork factor in QDM's methodology

Again, the goal of the system is not only to take advantage of each individual component, but also to allow businesses to profit from the synergy of the technologies and theories. Each component benefits from the others. For example, the processes being automated by the workflow module are also being analyzed, discussed, and honed with the help of the process awareness created by the GUI and the improved communication and collaboration made possible by the groupware platform. These interconnected modules form a powerful, responsive system that helps businesses achieve their goals by facilitating effective teamwork in a "different time/different place" paradigm.

The Groupware Platform

Perhaps the most critical design decision in the entire SBIR effort was selecting the platform on which to build the system. The ability of the other modules of the system to work effectively together would depend largely on the flexibility and robustness of the Groupware foundation.

QDM chose Lotus Notes®, a product still in its infancy at the time, as the baseline to which all other functionality would be added. QDM recognized Lotus Notes' power as a group communications forum. Such features as Client/Server Architecture and Database Replication make this platform a solid foundation from which to build complex, integrated, group-oriented software systems.

At the time QDM selected Lotus Notes as the groupware platform, effectively no competitive product was on the market, as is still the case four years later. Several unique features made Lotus Notes an intelligent choice.

- The ability to operate in a mixed networking environment (e.g. Novell, LAN-MAN, Banyan VINES, etc.) and a variety of hardware platforms and operating systems (e.g. IBM/PC, Macintosh, and Unix). Such mixed environments are common, especially in large organizations.

- The power and versatility of Lotus Notes documents. They can capture, store and route everything from simple text to spreadsheets, graphics, scanned images, and even full-motion video. This power is consistent with (indeed, at the forefront of) current multimedia trends.

- The organizational capabilities of Lotus Notes views. Lotus Notes views are relatively easy to build and are powerful ways to categorize and work with Lotus Notes documents.

- The embodiment of the many-to-many paradigm. Information is stored in a common repository (database), so entire groups can work together with these documents and views.

Lotus Notes embodies two important characteristics, which made it an ideal choice for our effort. First, Lotus Notes is simply an operating system and development platform for group applications. Much like DOS, Windows, OS/2, or any operating system required to program and subsequently operate a spreadsheet or word processing application, Lotus Notes is an environment that allows one to program and operate workgroup applications such as a client tracking system, Help Desk, or group-oriented project management application.

Secondly, Lotus Notes is a platform that provides both private and public workspace. Using the electronic mail component of Lotus Notes, you may send messages directly to other individuals "one-to-one." Yet if users choose, they may also enter and access information in applications that are publicly shared by many other users. Like a public file cabinet, information is stored and available if and when you need to access it. The unique replication capability of Lotus Notes allows access to the information from any place at any time.

The Workflow Module

As explained, the selection of a baseline workflow technology was neither a trivial nor a purely technological decision. Many technologies that enabled the station-to-station routing of forms, documents, or responsibilities were available, but QDM believes workflow can and should be much more than automation of the paper trail. We sought a system that had some theory behind it, a system that is not based on the routine shuffling of paper but on the ways in which people really work together to get the job done.

The workflow technology, like everything else that QDM integrated into the Groupware System for Multidisciplinary Participation, had to have a methodological link to management science. If some theory is embedded in the technology, the technology can act as an agent for improvement.

Daily use of the system will instill and consistently reinforce the effective practices that are built into the software.

The Basic Action Workflow from Action Technologies, Inc. (ATI) is the best example of a production workflow system that embodies a philosophy of how people work together. The ATI paradigm reduces all business processes to a linked series of "conversations" between a person who asks that a job get done (the customer in the process) and the person responsible for performing it (the performer of the process). Each conversation is a miniature "closed-loop feedback" system which is fully complete only when the customer declares that the work has been performed satisfactorily.

During our Phase I effort, QDM conducted extensive research in ATI's technology. We worked closely with ATI as a technology partner for early versions of the Workflow Management Server (WMS) engine, helping to define required capability for the product based on our intended uses. QDM worked together with ATI and Lotus Development Corporation to test this philosophy and technology in some of the earliest Lotus Notes/ATI workflow pilot programs. Both the theory and the technology that houses it have continually proven effective in describing and automating complex business processes for customers across a wide range of industries. Indeed, the philosophy and the method for embedding it into software have proven sufficiently relevant and innovative to warrant the awarding of two United States patents to the principal inventors at ATI.

Enabling Business Processes with the Basic Action Workflow

The workflow module that was built for Phase II of QDM's SBIR effort embodies the ATI methodology (fully described below). Some of the material that follows was extracted from ATI's *Actionworkflow™ Application Development Guide*.

The Basic Action Workflow, shown in Figure 7, is a unit of coordination between two parties; the customer and the performer. The workflow occurs in four phases, and is begun by a request or an offer.

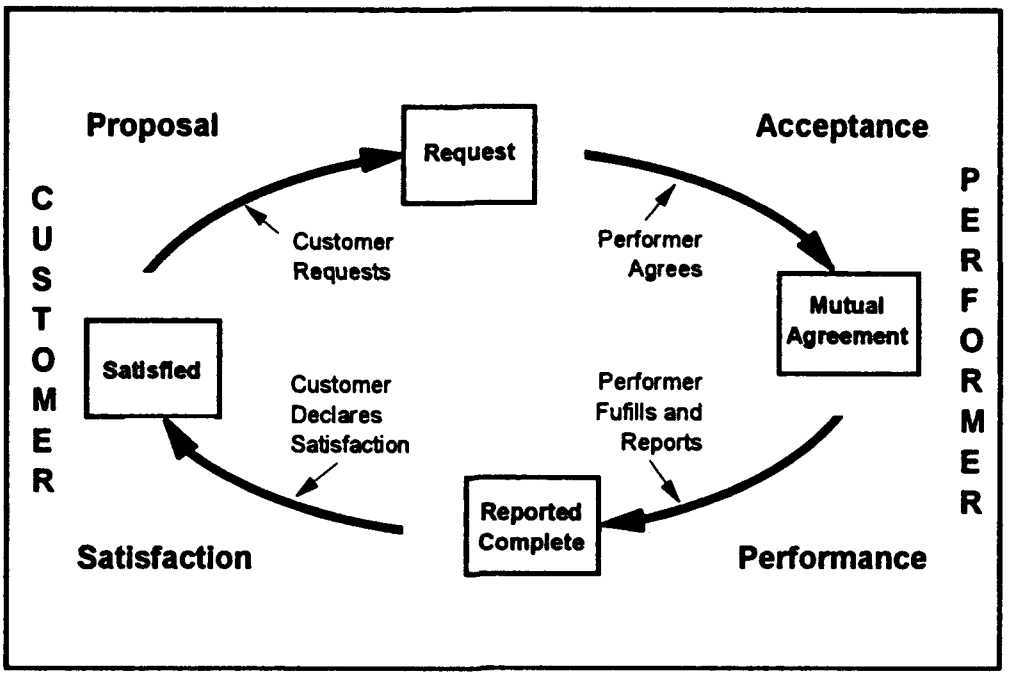


Figure 7
Basic Action Workflow as defined by Action Technologies, Inc. and embodied in the QDM SBIR Phase II Workflow Module

The customer asks the performer to fulfill some action. This request occurs during the "initial" phase of the workflow. In the next phase, "negotiation," the performer can agree, decline or counteroffer the request. If agreement is reached, the performer fulfills the request and declares fulfillment in the "in progress" phase. Finally, the customer declares satisfaction or dissatisfaction with the work of the performer in the "completing" phase.

This structure is designed to be a reflection of what people do while coordinating action with each other every day. By making the terms of the agreement explicit with acts of coordination, it is now possible to observe coordinations better and to design tools and applications to support coordinating our actions better.

The basic action workflow is made up of twelve workflow acts. If no exceptions exist in the workflow, the four acts of request, agree, declare fulfillment, and declare satisfaction will move the transaction from beginning to completion with a satisfied customer. This progression is referred to as the "no-exception" path of the workflow. The fifth act, declaring dissatisfaction by the customer, is a response to the performer declaring completion. This dissatisfaction puts the process back into the "in progress" phase until the customer is satisfied.

The state of a workflow is one of eight states that precede or follow workflow acts. Counteroffer and the four acts of negotiation are included in the state "In Negotiation." Figure 8 provides the state codes used in the Lotus Notes implementation of Workflow Management. These codes will be used in formulas to drive logic in the Lotus Notes applications. The workflow state before and after acts and the letter codes for each are also illustrated in Figure 8.

Act	State After	State Code
	Initiate (before request)	I
Request	In Negotiation	A
Agree	In Progress	B
Declare Complete	Completing	D
Declare Satisfied	Satisfied	S
Cancel	Canceled	T
Decline	Declined	U
Revoke	Revoked	V

Figure 8
Workflow State Before and After Acts

Other situations often occur, in addition to agreement when a request is made. Instead of agreeing to a request, the performer can make a counteroffer. If asked to "deliver the report you are working on tonight", a counteroffer might be, "it won't be completed until tomorrow night, but I can give you most of it tonight." A performer can decline to agree to what the customer asks, but offer some other conditions of satisfaction that might satisfy the customer.

In the Action Workflow, four acts have to do with negotiation, the interchange between a customer and performer that is started by a counteroffer. During negotiation the performer and customer offer different conditions of satisfaction until they reach agreement or terminate the negotiation. The acts that make up negotiation in the Action Workflow are illustrated in Figure 9.

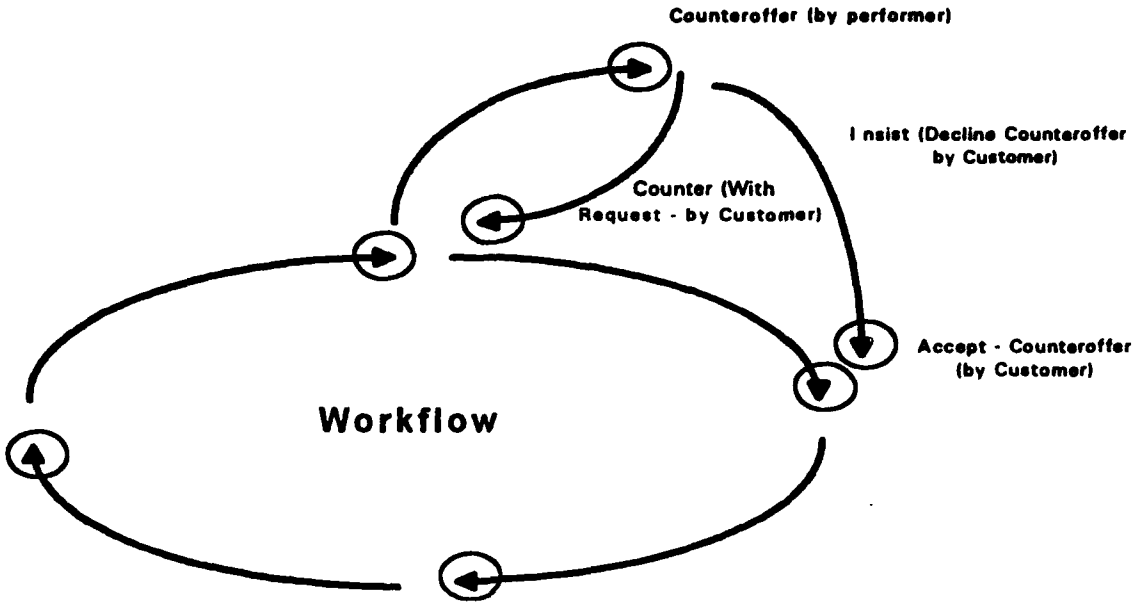


Figure 9
The Acts of a Counteroffer During Negotiation

When the performer makes a counteroffer to a request, the customer can make one of three state-change responses: agree with the counteroffer, insist on the conditions of satisfaction of the original request, or make another counteroffer. The customer making a counter response to a counteroffer is called a "counter-with request." The customer and performer can go on countering each other without limit. In actual negotiations the interaction eventually leads to an agreement or to termination.

The four workflow acts for negotiation after a request are:

- counteroffer by performer,
- accept counteroffer by customer,
- insist (which is a decline counteroffer) by customer, or
- counter (with a request) by customer.

When the customer counters a counteroffer, the performer is given the same options as for the initial request: agree, decline, or counteroffer.

A workflow can either complete with the customer declaring satisfaction or termination. Both the customer and the performer in a workflow can terminate it. The three acts that terminate the workflow are: decline, cancel, and revoke.

The acts that can cause termination are illustrated below. These acts can be taken in the phases shown in Figure 10.

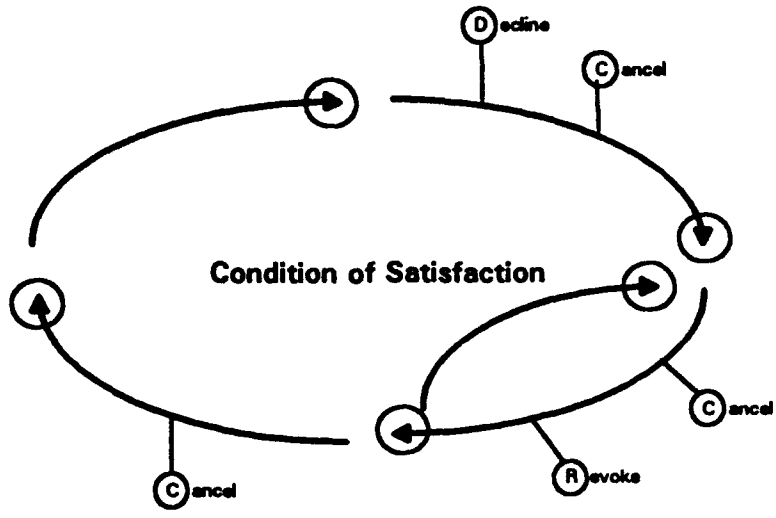


Figure 10
Termination Acts of a Workflow

Decline: When a customer requests an action from a performer, one response the performer can make is to decline. In declining, the performer is promising not to do what is asked and is terminating the workflow.

Decline is an appropriate act only in the negotiation, after a request and before an agreement. After an agreement, if the performer wishes to withdraw from the agreement, agreement is revoked.

Revoke: After an agreement, the performer can terminate a workflow by taking this action. Revoke can only happen between the agreement and the declaration of fulfillment, as is illustrated in Figure 10. A performer cannot revoke an agreement if it has already been fulfilled.

Cancel: Cancel is an act taken by the customer, canceling the request. A customer can cancel the request any time after the request is made, but before satisfaction has been declared. Thus, Cancel is an act available to the customer at any time in the three phases of Negotiation, In Progress, and Completing.

Phase I Modification — Process Improvement Business Opportunities Office (PIBO) Production Workflow System

In early 1991, during Phase I of this SBIR effort, QDM acquired the suite of software components licensed from ATI and worked closely with the ATI development team to understand the methodology described above and the technology that embodied it. Upon gaining this understanding, we then proceeded to the Phase I Modification of the effort, which began with the development and implementation of a production workflow system. Our observations of the results of this system, in combination with the feedback we would receive from the Process Improvement Business Opportunities Office (PIBO), would ultimately prove instrumental in the design and implementation of the Phase II Workflow Module.

We identified the Process Improvement Business Opportunities Office of the Center for Support of Technology Insertion (CSTI/PIBO) as the test bed for a pilot workflow management application. At the time, the CSTI/Process Improvement (PI) organization included, in addition to the FACTS office, the Productivity, Reliability, Availability, and Maintainability Program (PRAM) and the Reliability and Maintainability Technology Insertion Program (RAMTIP). PIBO determined what projects the organization would accept and which branch of the organization should manage the project. The application was to be a workflow-enabled version of the PIBO Project Tracker application (a Lotus Notes-based application that QDM had developed for PIBO under a separate contract). The Project Tracker application managed the flow of projects through a series of states and databases, from proposed to accepted to completed/closed. The project would move to the appropriate location in the system when its state changed.

The workflow-enabled Project Tracker would be more valuable because it would coordinate not only the movement of project forms based on their changing states but would also automate the actions of team members that were necessary for the project to change states. While the Project Tracker automated the management of project documents, the workflow-enabled Project Tracker automated the activities of people. The Workflow management component would allow the Lotus Notes groupware platform to alert performers about pending actions and assignments to teams and allow customers and managers to view the current state of a project and see whose next action is pending.

Before the prototype application could be developed, the PIBO business process had to be defined and analyzed to determine exactly the flow of work and responsibility around the process. A team consisting of QDM management consultants, a senior programmer, and a business process analyst from ATI interviewed several members of the PI community. The product of the interviews was a business process map depicting the PIBO process. (See Figure 11).

Using this map as the specification for how the PIBO process operates, an application that initiates the specific tasks in the listed sequence was designed. This map depicts a series of ATI-style "closed-loop feedback conversations" that govern the project review process. The process begins with a determination of a given project's relevance to the PI office by the PI Chief. Based on this determination, the project is then planned and launched: a team leader and team members are assigned, the project is further investigated and briefed, and a project plan is drafted, reviewed, and revised.

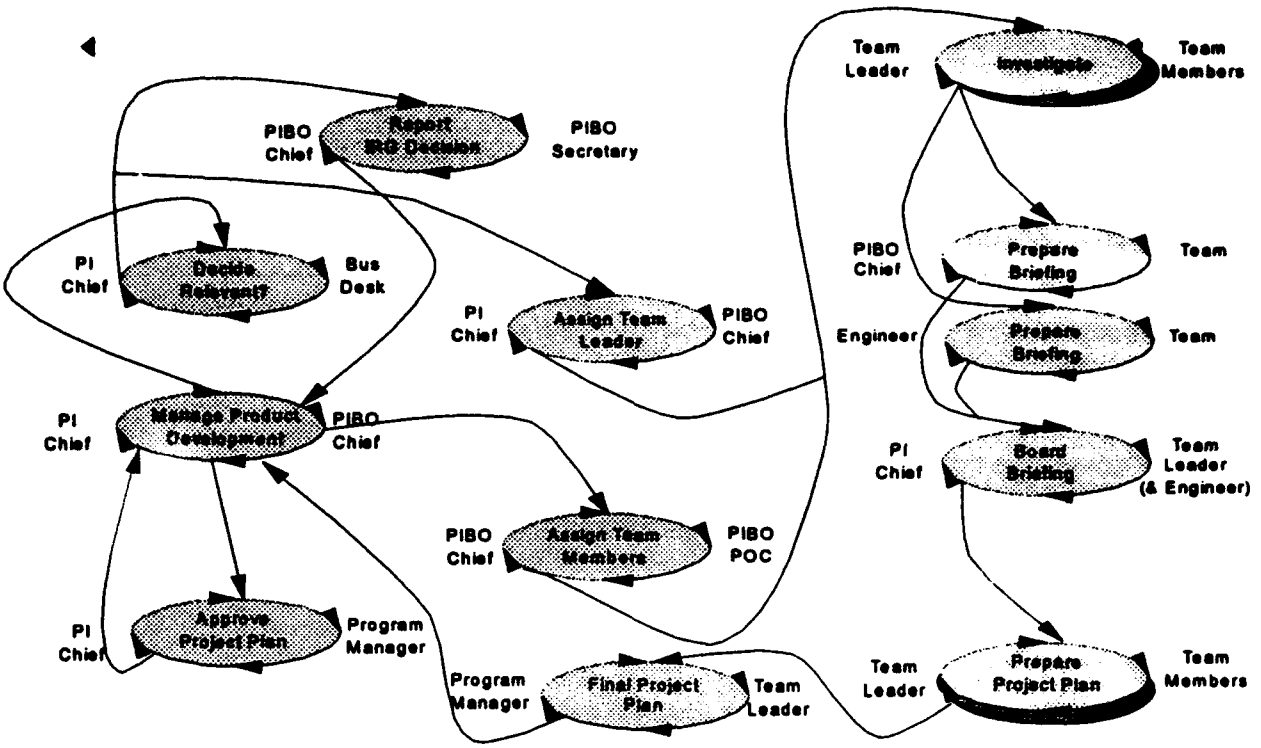


Figure 11
Business Process Map depicting the process in the PI Business Opportunities office as a series of interrelated workflows

After an initial review, several changes and enhancements were made to the workflow management Project Tracker system. In fact, the process was entirely re-mapped and redesigned several times because of changes in both in the process itself and in the organization that performed it. Organizational realignments within the Air Force brought about new and redefined steps in the process, all of which had to be accounted for by the system. Only after much realignment and juggling was the process sufficiently "frozen" to be automated by production workflow.

The resulting system, including a version of the WMS Engine licensed to QDM by ATI for purposes of prototype application of the technology, was installed for PI after finally settling on a design for the process. Representatives from PIBO were trained to use the workflow management application. Training focused on describing the steps of the PIBO process; from an end-user perspective, the system is simply a Lotus Notes application. A Notes-based application was established to collect and record user comments and feedback during the test phase. This feedback would be put to use in the development and production of the workflow system as the project extended into the Phase II effort.

Integrating Ad-Hoc Workflow Tools Into the Production Workflow Environment at Fasteners, Actuators, Connectors, Tools, and Subsystems (FACTS)

Both the International Data Corporation (IDC) and Professor Marvin Mannheim, a noted researcher at the Kellogg School of Management at Northwestern University, have come up with some distinctions with which to categorize workflow systems. The IDC defines three categories: Production, Administrative, and Ad-Hoc. Mannheim's distinctions, equally well accepted, are similar: Structured, Semi-Structured, and Unstructured. Both sets of distinctions use category labels that describe the types of processes that the category of workflow is designed to automate. The ATI technology discussed above, for example, is classified as "Production" or "Structured" workflow. As illustrated in the PIBO example, this type of workflow is generally used to automate a complex, rigid process. ATI's methodology and technology is the clear industry leader in using this type of workflow to automate this type of process. Recognizing this, QDM implemented this type of workflow as part of its initial Project Management deliverable to allow the management of Projects and Tasks to be automated electronically.

However, few processes can be strictly and completely defined from the outset, anticipating and allowing for the full spectrum of exceptions and contingencies. QDM, recognizing this, began to develop Ad-hoc (or "Unstructured") workflow tools for common processes that do not always fit into a rigid pattern of work. As we developed these tools, it became more and more clear that such processes are generally pervasive throughout an organization. These simple processes are based more on the single Basic Action Workflow loop than on the complex series of linked "conversations" that are used to describe more complex, workgroup-specific processes, as illustrated in Figure 12.

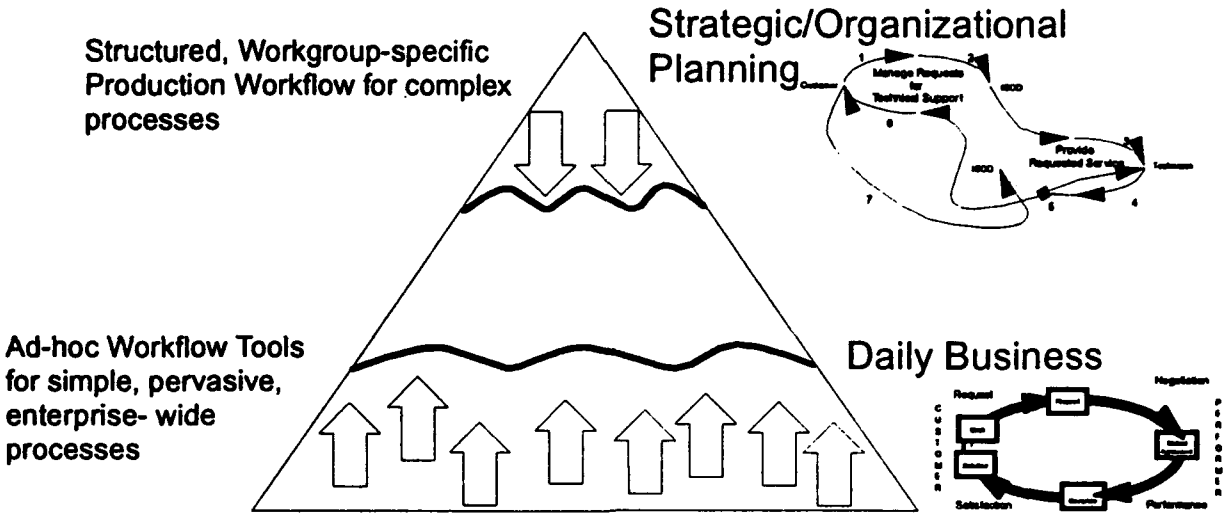


Figure 12
Production workflow best automates complex processes, designed by the management level of the organization, for specific workgroups. Ad-hoc tools best automate less defined, less predictable, more pervasive processes.

A niche for methodolcgically sound ad-hoc workflow tools to help people perform the critical tasks that are routine in the course of daily business clearly existed. The most common such process in any working environment is the simple act of asking one of your associates to perform an activity. QDM terms these everyday, ad-hoc requests "Action Items" and provides a tool that streamlines the delegation, performance, and completion of these simple tasks.

The tool takes the form of an electronic-mail-style document that travels between the customer and performer of the Action Item as the process progresses. The new action item capability incorporates the Basic Action workflow methodology by allowing a performer to negotiate a task with the customer prior to accepting the assignment, and will require that the customer, rather than the performer, declare satisfaction. Despite the identical underlying methodology, the Action Item performs quite a different function than an ATI workflow system. While the structured ATI implementation requires the execution of exact steps of the workflow based on predefined rules, the flexible QDM adaptation provides simple, fundamental tools that are available for use when needed as dictated by business situations. These tools epitomize the Ad-hoc or "Unstructured" workflow category.

QDM's Ad-hoc workflow tools are "Forms-based," a technological distinction that has significant practical ramifications. Stated simply, the "intelligence" (e.g., the rules for what step should occur next based on certain conditions) behind the routing of "forms-based" workflow tools is contained within the form itself. The Action Item, for example, has logic built right into it that routes the form and changes its state based on the actions that have been taken on it. Conversely, production workflow tools must "look up" the "rules" for routing before they can be processed. These "rules" are generally contained within a separate database in a different location on the server.

What all this technology means from a practical/usage standpoint is that a user of a production workflow tool needs to be directly connected to the server containing the routing "rules" in order for progress to be achieved in the workflow in a single, timely step. Ad-hoc tools, on the other hand, can be used throughout a distributed environment and across geographic locations as simply as sending an electronic mail message. An example will help illustrate: Charlene works at corporate headquarters in Charlotte, Larry at a field site in Los Angeles. If Larry wants to take action in one of Charlene's production workflow processes, he will need to dial into her system in Charlotte and communicate his work via modem in order for it to be processed. If, on the other hand, Charlene has assigned Larry some work with an Ad-hoc tool like an Action Item, progress in the workflow process can be achieved simply and immediately through electronic mail.

QDM used Application Programming Interface (API) code and forms-based routing rules to create the logic for several ad-hoc workflow tools. Like the Action Item form, these tools each embody common, pervasive business processes. Gathering input, building consensus, and soliciting approval are the types of simple activities that are critical to the process of getting work done on a daily basis. The additional forms-based tools that were developed at this stage of the effort included the Brainstorm, Opinion Poll, and Request Approval forms. These provide users with the ability to automatically solicit and tally group input and opinions and to route a request for approval through the appropriate chain of command in much the same way the Action Item

automates the assignment and tracking of individual responsibilities. The four forms, taken together, are now known as "Routing Forms."

The ad-hoc functionality was fully integrated with FACTS's existing production workflow system and with individual users' mail files. While the production workflow processes took place entirely within FACTS's central, shared Lotus Notes database, individual ad-hoc Routing Forms are merely initiated there. As users act on Routing Forms in their Mail files, the copy of the form in the shared database is updated with their progress. The shared database is the central site for teamwork, individual Mail files are the central site for individual responsibility, as shown in Figure 13.

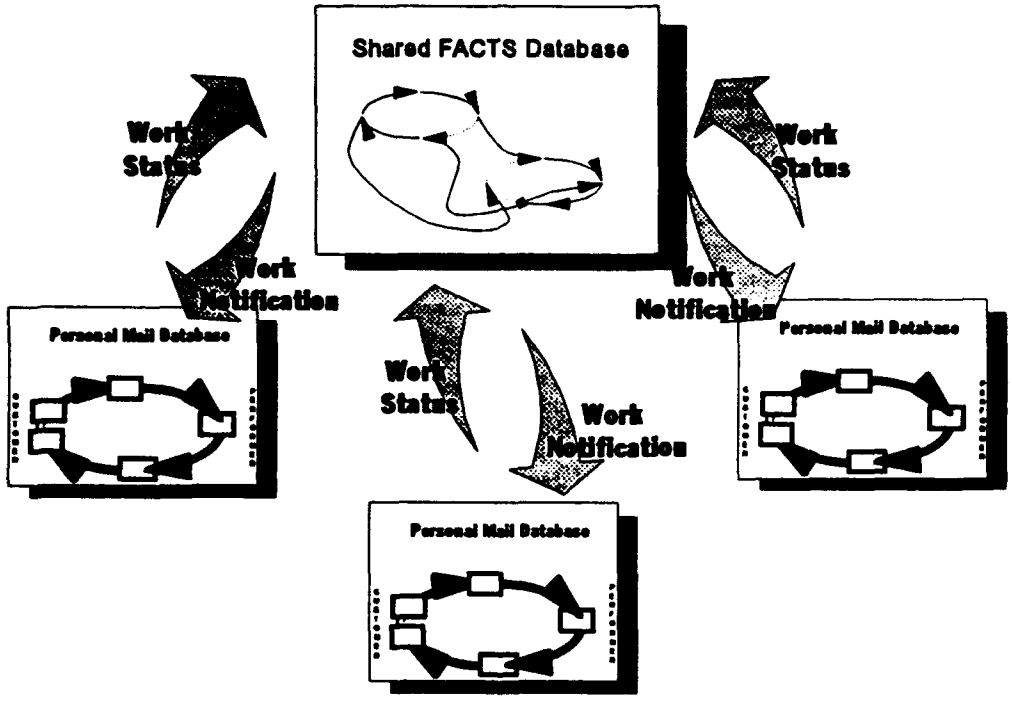


Figure 13
Basic interaction between databases and Mail files. Ad-hoc processes are accomplished in the Mail file, more complex production processes are governed in workflow-enabled shared databases, and status of each type of process is passed between locations.

Quality Decision Management's Commercial Efforts in Parallel with Phase II Small Business Innovation Research Effort

As QDM developed our early adaptations of ATI's production-based workflow and our own forms routing based-workflow for the SBIR effort, we recognized the strong potential for immediate commercialization of this SBIR technology. Lotus Notes had been on the market for more than two years, and the installed base was reaching the 300,000 user mark. As organizations adopted Lotus Notes, they began to realize the amount of time and resources required to develop and deploy applications designed to operate in the Lotus Notes environment. The notion of off-the-shelf applications had considerable appeal to the Lotus Notes market, and

QDM seized this opportunity to commercialize the SBIR technology into a ready-to-use workflow-enabled Lotus Notes product.

QDM conducted our own unofficial Phase III SBIR effort in parallel with our ongoing Phase II effort. Using funds secured from private investment capital, QDM added additional features and functions to the SBIR workflow technology. We entered into an agreement with ATI to license the Workflow Management Server engine and ship it as part of a commercial product. We conducted a rigorous test of the software and produced the necessary product documentation and packaging. With these efforts, in March, 1993, QDM launched a commercialization of the SBIR technology called **Quality *At Work*®**, Version 2.0. (QDM had previously introduced a suite of Lotus Notes applications which were trademarked **Quality *At Work***.)

The Final Workflow Prototype: A Licensed, Fasteners, Actuators, Connectors, Tools, and Subsystems (FACTS)-Specific Customization of Quality Decision Management's Quality *At Work*®

To ensure that the FACTS office had the latest technology, QDM, under a specification agreed to in a modification to the SBIR contract, agreed to transition the FACTS Project Management system to an underlying architecture of the commercial version of QDM's **Quality *At Work***. **Quality *At Work*** was furnished to this organization because the expanded Workflow and Graphical Front End technology offers the widest range of functionality and is easily maintained even beyond the conclusion of this SBIR effort. The commercial version of **Quality *At Work*** will not be furnished as part of the formal software deliverable at the conclusion of this effort, with the exception of the license granted to FACTS. Other Government offices that choose to operate the fully expanded prototype system will be required to purchase necessary commercially available software, such as Lotus Notes and **Quality *At Work***.

The **Quality *At Work*** system represents a more advanced maturation of the core technologies that QDM developed and delivered to the FACTS Office for the SBIR effort. This system integrated multiple Lotus Notes databases, all of which were equipped with **Quality *At Work*** Routing Forms. Each database was also fully integrated with individual Mail files per the **Quality *At Work*** paradigm.

The three databases that form the core of the FACTS **Quality *At Work***-based architecture are the Problem Documentation database, the Project database, and the Closed Project database. A fourth database, Customer Feedback, provides a collection point for all "customer issues" that are generated on behalf of FACTS customers from the other three databases.

The Problem Documentation database houses reports generated by FACTS "field service visits." Based on the findings detailed in these reports, a decision is made whether or not to begin an "official" FACTS project. Those investigations resulting in new FACTS projects are initiated in the Problem Documentation database by composing a new project summary document. Once initiated, the new project summary will by copied (using QDM's forms routing engine) to the FACTS Project database where it will be worked until completed. Completed projects are archived in the Closed Projects database. The basic architecture is shown in Figure 14.

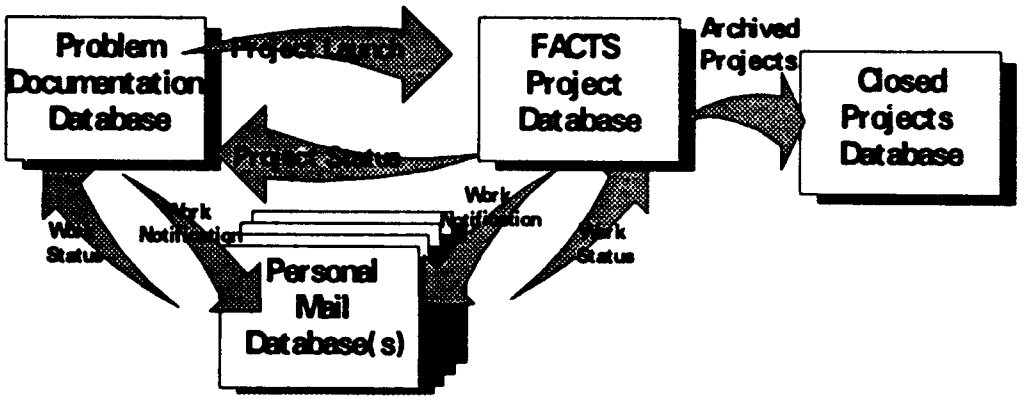


Figure 14
Basic architecture of FACTS-specific customization of Quality *At Work*. In addition to the Problem Documentation, FACTS Project, and Closed Project databases, a Feedback database (not pictured) gathers comments from the three others.

The Project database was streamlined to match the FACTS process while maintaining existing project management capabilities that had been implemented earlier (as detailed above). In fact, this process is very similar indeed to the PIBO process that we had initially automated with production workflow. The biggest difference between the two systems is that this iteration is much more flexible because of the addition and integration of ad-hoc workflow tools. For example, rather than automatically assuming the steps in the workflow (assign team leader, assign tasks, etc.), the workflow forms are there for the user to use when and if appropriate. In addition to providing users with this flexibility, these tools also tightly integrate individual Mail files with the databases which house the processes. Users are more completely and effectively involved in the process because of the design of the ad-hoc workflow tools and the system architecture.

Lotus Notes is an excellent environment that offers access to public and private workspace. Mail is a private space database. Problem Documentation, FACTS Projects, and Closed Projects are public databases. In a routine Lotus Notes installation, these databases would be separate islands of information. Breakdowns can occur as information and work assignments begin to accumulate in these separate islands. The QDM design does not treat databases as separate islands of information but creates connectivity that models the process and monitors the status of work among and between databases. As opinions are solicited from the public FACTS Projects database, an Opinion Poll form is routed to the private mail database of the people involved in that specific process. There is no risk that the intended respondents will overlook the request. Work, in this case the response to the Opinion Poll, is conducted in the users' private mail database, but the response is automatically routed back to the public FACTS Projects database. As group consensus accumulates, everyone can view the collective input.

This design creates a closed-loop feedback system that is vital to the successful coordination of group activity. The QDM architecture is an effective integration of private and public space that ensures the benefits of improved information access without the burden of excessive information overload.

When a project is completed, the entire project (project summary and all related/relevant documents) is moved to the FACTS Closed Project database. The Project Summary document is maintained by **Quality *At Work*** across all three databases. Linking the entire FACTS process via the **Quality *At Work*** architecture in this way provides an integrated groupware system of workflow-enabled databases from which accurate metrics can be gathered and displayed by an intelligently designed Graphical User Interface.

Process-Oriented Front End Module

The front end is a crucial piece of the Groupware System for Multidisciplinary Participation. In order to maximize the ability of the front end to foster and facilitate process awareness, the tool must be embraced by the user community. The best way to create this acceptance is to make the tool powerful, and easy to use and understand.

The power of the GUI stems from its ability to read and display data from the workflow module, whose user interface is somewhat limited by comparison. One example of this limitation is that the Lotus Notes platform, though allowing any number of sophisticated and informative views of an individual database, is unable to compile information across numerous databases. For example, a user of the Lotus Notes interface would not be able to view all projects being performed on behalf of a given customer in all databases (i.e., Sales Project, Consulting Services Project, Customer Complaint Resolution, etc.) throughout the system. A well-designed GUI could compile that data easily.

Lotus Notes views, in addition to being confined to the data in a single database, are also relatively fixed as compared to the dynamic user-defined queries of a process-oriented front end. Adding or modifying views in Lotus Notes requires programming, but shifting the focus of the query for information in a GUI can be as easy as pressing a button. For example, someone interested in the ZBT Corporation can take a view of the projects being done for them and see that several are running late. A process view will show where the bottlenecks are. Digging deeper will show who is responsible for performing the processes that are holding things up. Users of a GUI are able to gather the information they seek by dynamically adjusting the focus of their queries, zooming in or backing out "on the fly," rather than constantly shifting between a predefined set of Lotus Notes views.

Another limitation of the Lotus Notes user interface is that it is largely text-based. Views of a given database's information take the form of indented outlines. A process-oriented front end module could not only compile this information with that of other databases, it could also display the results in colorful, easy-to-understand charts and graphs. Bar charts and process maps are much more informative and user-friendly than text outlines. They are also analyzed much more readily, giving users insights into the way processes are being performed and, more importantly, how they can be improved.

From the beginning, QDM established criteria for selecting a robust, user-friendly GUI with which to display data gleaned from the workflow module of the SBIR effort. These criteria included:

- a tool that could graphically depict a process both as a whole and as the sum of its individual parts,
- relational functionality that contextualizes a user's role and activities within the process,
- information visualization tailored to the way a user easily understands data (i.e., use of pictures, graphics, charts, numbers, words),
- reporting standards that provide status and feedback about the process and individual components of the process to users, and
- convenient access to different data sources and different data types.

As our original intent was to use existing technology, not invent a new graphical interface, identifying these criteria proved to be a much simpler task than finding a GUI tool that met them.

The Failure of Notebook as a Candidate Environment for the Phase II Front End

In the initial stages of our search for a GUI tool with which to build a Process-Oriented Front End, QDM acquired access to a toolset in the preliminary stages of development from Lotus Development Corporation, code-named Notebook. During the Phase I Modification stage of our SBIR effort, QDM evaluated Notebook's viability as a tool for building the Process-Oriented Front End to our system. QDM was uniquely qualified to perform this evaluation; we were working closely with the Lotus Development Corporation as a Notebook Design Partner. Thus, we could not only evaluate Notebook as a tool, but also influence its design with requirements, suggestions, and feedback such that the functionality we desired could be incorporated into the commercial version of the product.

Our intention was to build a demonstration with Notebook operating as the interface to the PIBO workflow application. The purpose of the Notebook demonstration was to provide a mock-up of the process-oriented GUI in the early stages of the SBIR project. Throughout this period of activity, we continued to test Notebook capabilities in an attempt to build the required mock-up system. The result of this testing and research proved that the pre-alpha version of Notebook was severely limited. Although the eventual release of Notebook was planned to support many of the functions required for our development effort, completing anything more than a limited demonstration using Notebook in its available state was not possible.

This demonstration marked the beginning of the difficulties presented by Notebook. The product was supposed to include very useful features, including data access (to Sybase®, dBase®, Informix®, Paradox®, Lotus Notes®, and 1-2-3®), a script language, Dynamic Data Exchange (DDE) client and server, Object Linking and Embedding (OLE) client, and full-featured WYSIWYG (computer-ese for What You See Is What You Get) GUI with menu builder and user-programmable smart icons. Although these features would have proved quite helpful in developing our Process-Oriented Front End, the Notebook production schedule continued to slide and prereleased bugs continued to hamper our SBIR development efforts.

QDM realized more than 18 months ago that these limitations would prohibit the delivery of a functional GUI in the SBIR time frame and discontinued further development work with the Notebook toolset. Despite this product's brief reemergence as a viable candidate several months later (due to some changes in Lotus' development strategy), this decision proved to be an intelligent one. Notebook, now called "Notes ViP," was announced and demonstrated at the Lotusphere '93 conference in December 1993, but remains far behind our schedule and unreleased at this writing.

Exploring Other Candidates for Graphical User Interface Development

During this period, QDM also met with representatives from the Trinzic Corporation (known at that time as Channel Computing) to discuss the possibility of using its product Forest & Trees® as the development environment for the GUI. Forest & Trees contains customized application development tools, performs data retrieval across a wide range of platforms, and consists of a User Interface (UI) to graphically present information in a variety of ways.

One feature of Forest & Trees that was especially attractive in our case is that the product is designed to run like an electronic dashboard monitoring specified data. It also comes standard with links to common data formats such as 1-2-3, Excel®, dBase, and Paradox. Links are also optionally available for several SQL-based data systems. As this product was more mature than Notebook and already incorporated important required features ("gauges" to monitor data, programmable zones on the screen, a very flexible UI), we considered the use of this product as the basis for our UI.

Another important player in the user interface evaluation was the Design OA® environment from Meta Software Corporation. QDM used Design OA as the development environment for Memory Jogger Plus+ PC™, our seven management and planning tools software product. Design OA was used much like one would use ObjectVision® or Forest & Trees to build a custom application, including extensive C programming interface with the Design OA libraries.

Although the benefits to both Design OA and Forest & Trees are often tremendous, serious limitations to using such products as the basis for customized application development can exist. The most important benefit is the ability to take advantage of proven, existing technology, which can save considerable development time and effort. The most serious limitation was that we could only make our application do what the software vendors allowed us to by using features compiled into the product. Even using programming interface languages, we were limited to working with the designed features compiled in object libraries.

QDM encountered several instances of this limitation while developing our Memory Jogger® product. Several desirable capabilities such as DDE, floating palettes, and smart icon bars were not included in the product and were unavailable because we did not have access to the Design OA source code. Thus, as a candidate for the SBIR development, Design OA presented these same limitations.

To combat this problem, QDM (separate from the SBIR contract) purchased the source code to Design OA for both Windows and the Macintosh from Meta Software. We started to familiarize

ourselves with the code to determine how to modify the environment for our SBIR requirements. Unfortunately, the source code proved difficult to manage; much code reorganization would have been necessary for us to achieve our desired results. Also, despite Design OA's power as a long-term platform, it did not prove agile enough as a prototype environment to handle QDM's iterative Rapid Prototype Development Approach.

Many other candidates were thoroughly evaluated as possible environments in which to develop the Process-Oriented Front End. In addition to the three products discussed above, QDM also examined products such as ObjectVision®, Toolbook®, Neuron Data's Open Interface®, and Corporate Memory Systems' CM/1®. Such evaluations continued through early 1993 when, after rigorous testing, QDM settled on Microsoft's Visual Basic 2.0® as the production environment for the Graphical Front End.

Visual Basic 2.0: Production Environment for the Graphical Front End

Visual Basic was chosen on the basis of its being an established, well-respected and supported product that has the capability to read information from the workflow module and then clearly display it graphically in a variety of user-defined formats. Our investigation into the variety of GUI candidates made it clear that the actual user interface was just as important as the tool's data acquisition capabilities. Visual Basic provided us with a strong blend of these two important concepts and provided us with the requisite flexibility, clarity, and graphical sophistication for our Process-Oriented Front End.

The overall functional objectives of the Process-Oriented Front End were to provide the following.

- **Flexible, User-Definable Queries.** Allow users to focus on specific information according to their individual needs and interests. Enable users to get the information they want, rather than being restricted to a limited set of pre-defined views.

- **Graphical Displays of Processes.** Display the results of these queries in a clear, concise manner. These displays should contain current statistics and historical information about processes in the system.

- **Contextualized Information.** Make clear to the user the context of the displayed information. This clarification will facilitate analysis of the data and help target areas for action.

The Process-Oriented Front-End Graphical User Interface is designed to format and display information generated in the workflow module and present it to users in a manner that fosters and facilitates analysis.

The system functions follow:

- **Data acquisition from the workflow module.** The power to read data and generate graphs and tables that reflect this data in a reasonable amount of run-time.
- **User definition of selection criteria.** An initial design that makes it easy for users to define their specific information needs.
- **Tools that foster and facilitate process analysis.** Carefully designed to enable users to fully understand the business processes and to use this knowledge to analyze and improve the flow of work through the organization.

Of course, the first step in designing the GUI was providing it with the means to read the data from the workflow module. Through our thorough investigation of candidate environments, it became evident that no available graphical development environments directly accessed Lotus Notes databases without additional custom development. QDM developed a program that would essentially serve as a Lotus Notes Data Pump, transferring Lotus Notes data from the databases in which it resided (known in Lotus Notes as .NSF files) into Visual Basic files that could be read and processed by the Front End. The Lotus Notes Data Pump is shown graphically in Figure 15.

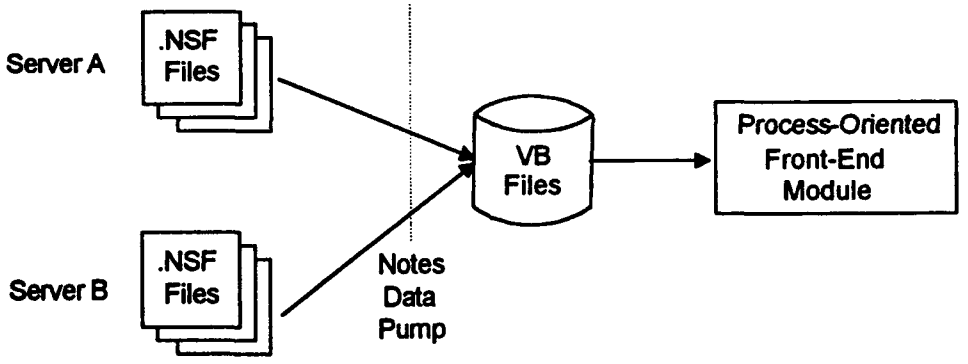


Figure 15
Basic architecture of the Data Pump developed by QDM to transfer data from Lotus Notes to the Process-Oriented Front End

The initial prototype allowed for graphics to be generated from two primary foci: customers for whom work was being performed or employees/team members who were responsible for performing it. Figure 16 shows the initial configuration.

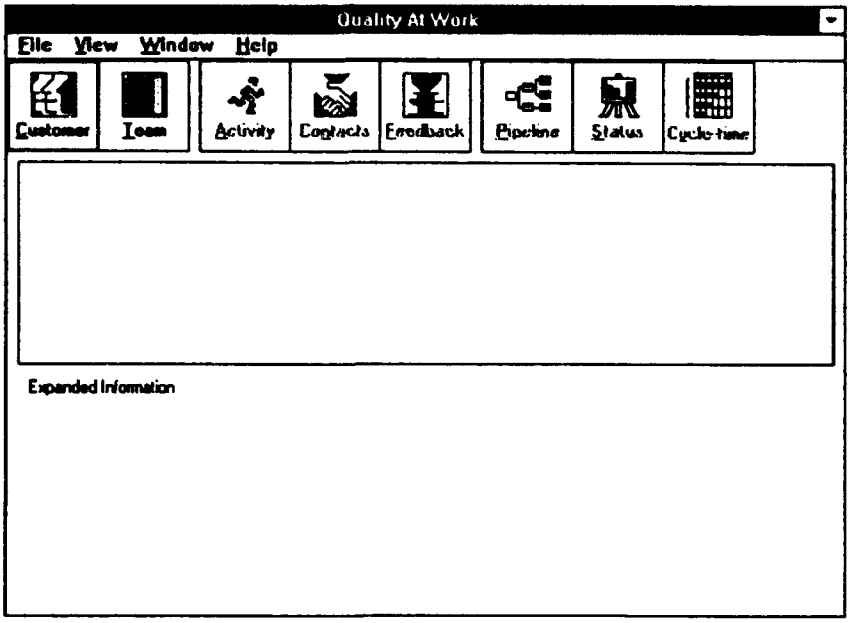


Figure 16
Opening screen of initial prototype GUI. First level of user-defined query was either Customer (for whom work was being performed) or Team (person/people who were responsible for performing it).

The results of these user-defined queries were graphically displayed in a way that facilitates analysis. Charts and graphs concisely conveyed information that increases awareness of business processes and the ways in which they might be improved. Users will use the graphical presentation of this data to help them identify and assess process bottlenecks, individual productivity, and areas for improvement. This interface provided two graphical displays of the progress of either type of information: state or status. State identifies the processes' location in the pipeline or steps of the workflow, as illustrated in Figure 17.

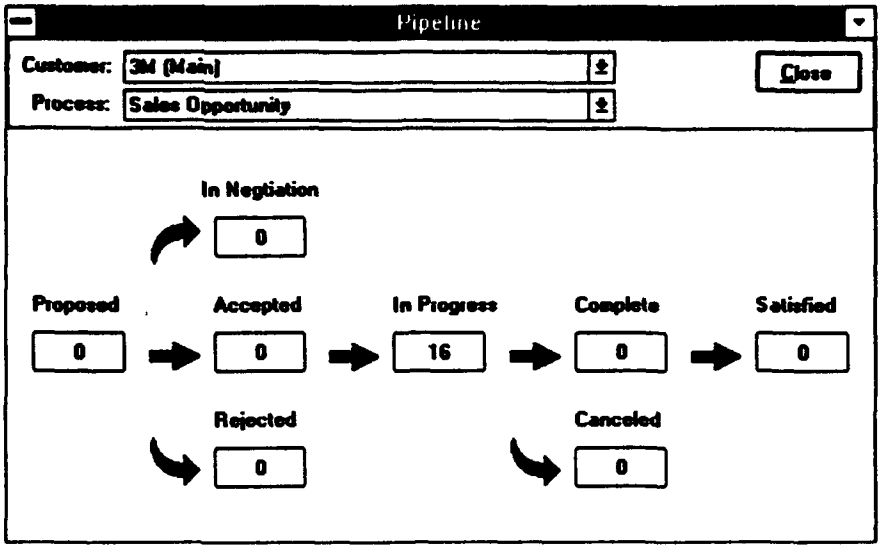


Figure 17
Example of a State or Pipeline view generated using the initial prototype of the Process-Oriented Front End. Additional information is available by selecting a given Customer, Process, or State.

The State or Pipeline view illustrated above gives users a more complete understanding and awareness of the steps required to complete a process. With this awareness often comes insight into where bottlenecks are and how the process might be improved: Are projects slow to be accepted or completed? Are a large percentage of projects being rejected or canceled? Are these trends acceptable or indicative of poor practices?

The status display illustrates the timeliness of a process, as shown in Figure 18. As opposed to seeing a detailed view of the process and how work is flowing through it, this view examines the entire process as a unit and measures it against its initial time estimate. One example of the use of the status view would be to delve into the nature of processes that are running late. Is a given performer common to many such processes? Are the initial time estimates reasonable? How can operations be improved to ensure that scheduling is accurate and that work gets done on time?

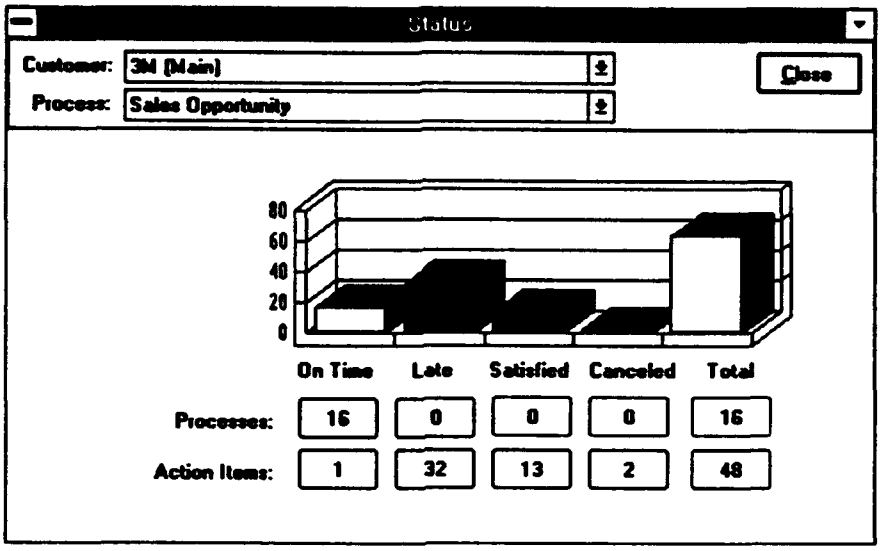


Figure 18
Example of a Status view generated using the initial prototype of the Process-Oriented Front End. Additional information is available by selecting a given Customer, Process, or Status category (e.g. On Time, Late, etc.).

The overall design of the graphical front end presented information from a management and user workstation overview. The initial GUI prototype displayed statistical analysis of the current state (or a historical state) of sets of processes that met some specified criteria. In contrast to pre-defined Lotus Notes views, this interface allowed the user to select check boxes and radio buttons until the desired set of documents was located. Rather than being restricted by a Lotus Notes view to documents in a single database, the user of this interface had the ability to compile information that is read from documents across multiple databases.

The Final Front-End Prototype: Fasteners, Actuators, Connectors, Tools, and Subsystems (FACTS)-Specific Project Monthly Review Reporting System

The response to this initial prototype, and to the FACTS-specific Project Management workflow system, was positive enough to warrant further development and customization of these tools for the FACTS office. Additional functionality was added to the baseline GUI prototype to create a Front End that could quickly generate the types of charts that are typically included in FACTS office monthly reports. These modifications were requested by the FACTS office after it had experimented with the original software deliverables in a pilot environment. FACTS personnel discovered that these technologies could be extremely useful as part of their standard ways of doing business. For example, they could access summary and statistical information at any time, rather than compiling the data each time in preparation for a status briefing. As a result, FACTS asked QDM to customize the workflow and GUI tools to fit their needs (see Figure 19.)

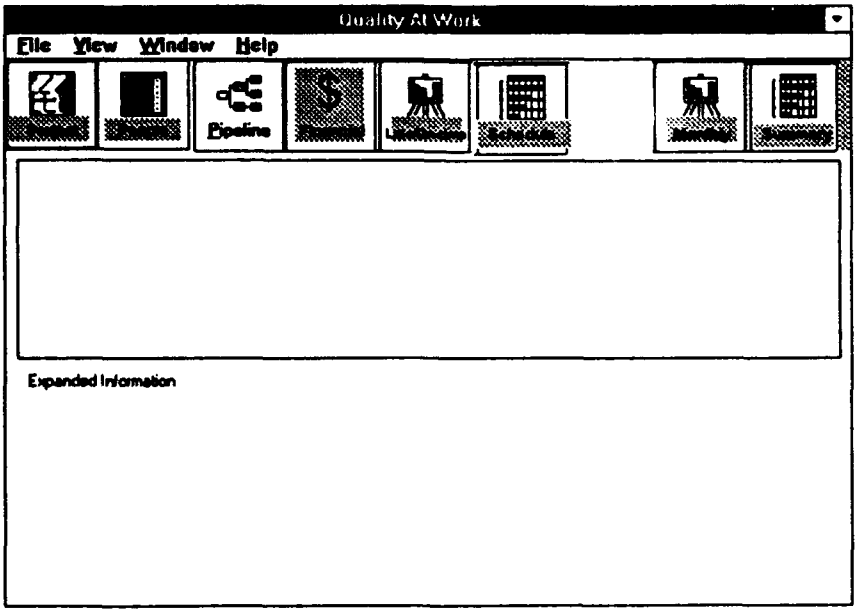


Figure 19
Opening screen of FACTS-specific prototype. In addition to Project and People foci, Monthly and Summary reports are also available.

In addition to the Project and Team member foci offered by the initial prototype, the FACTS-specific Program Monthly Review (PMR) also gave users the ability to generate monthly and yearly project summaries (the two buttons on the far right of the screen above). Monthly summaries display a bar chart of the pipeline states of all projects across every branch of the FACTS office for a given month and year. Yearly summaries offer "By Status" and "By Team" views of projects for a given fiscal year. Pipeline information within these summaries is broken down by division/type of project (Fasteners, Connectors, Tools, Subsystems, Process), and high-level summaries of all FACTS activity are also available.

Additional FACTS-specific information has also been added to the Project and People queries. The four middle buttons on the screen shot above (Pipeline, Financial, Late/On-Time, and Schedule) give FACTS users specific, meaningful metrics with which to judge the progress of the office's various processes. For example, the generic pipeline button that was developed in the initial prototype has been modified to specifically reflect the FACTS teams and process. When FACTS users select the pipeline button (after having selected a group of projects or team members about which they would like to generate these metrics), they are presented with the set of options shown in Figure 20.

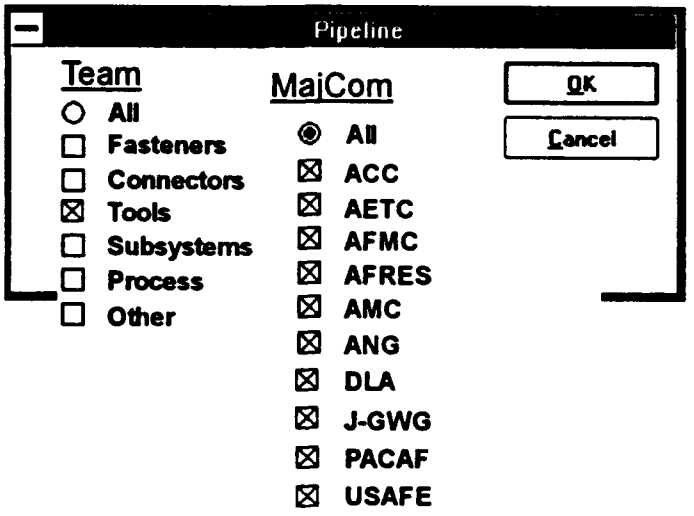


Figure 20
The list of Teams and Major Commands about which FACTS users can generate pipeline and other metrics using the FACTS-specific Graphical Front End

The user, after selecting the Teams and Major Commands about which he would like information, is presented with the Pipeline view shown in Figure 21.

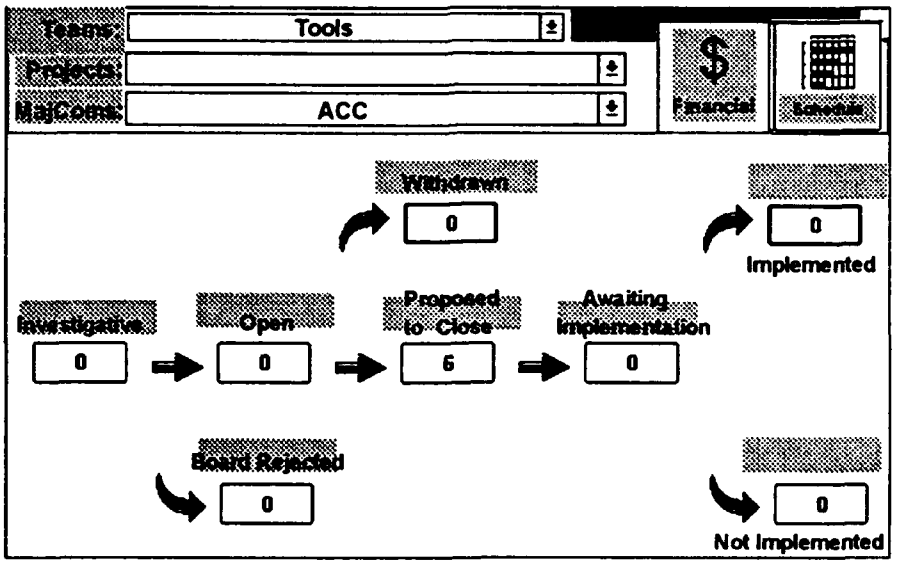


Figure 21
Sample pipeline view of Tools Team projects for the ACC MajCom. Note that this process outline specifically reflects the FACTS process and, thus, differs from the general pipeline view developed in the initial prototype GUI.

The Financial and Schedule buttons in the top right corner of this screen give average Cost-Benefit analyses and Actual vs. Planned/Baseline schedules for the selected set of projects. The user may click on a given pipeline state to dig into details of individual projects. The user can easily maneuver within the GUI to dig into deeper detail or to back up to a higher level and get the "big picture" view. Queries can be organized by project, team, Major Command, pipeline state, or any combination of these factors.

Using these criteria, FACTS users can also generate metrics with the Late/On-Time button on the initial screen of the GUI. The Front-End is capable of quickly generating bar charts which measure actual progress versus planned or baseline schedules. These metrics can be generated to thoroughly examine a single project or to get a general sense of project progress within a team or MajCom.

All of these query possibilities were created in response to specific requests made by the FACTS office. The metrics generated are the very ones used routinely by the FACTS office to measure performance and progress and by which to gauge improvement. The Process-Oriented Front End evolved from a generic Process Awareness tool to a bonafide, FACTS-specific Project Monthly Review application.

Integration of Management Tools

The Initial Proposal

The initial proposal for the Groupware System for Multidisciplinary Participation detailed a third section of technology in addition to the workflow and graphical front-end modules. The purpose of this third section was to provide generic tools that would be widely useful when performing analyses to justify decisions, prioritize alternatives, evaluate options, and develop a plan of action. These tools were to embody concepts such as Quality Control (QC), Effective Planning, Continuous Improvement, and TQM.

The Seven Quality Control tools that were suggested for incorporation into the system are shown in Figure 22. They were to implement the techniques of:

- Hoshin Planning,
- QFD,
- Statistical Process Control (SPC),
- Benchmarking,
- Pareto Charts,
- Flow Charts, and
- Cause and Effect Diagrams.

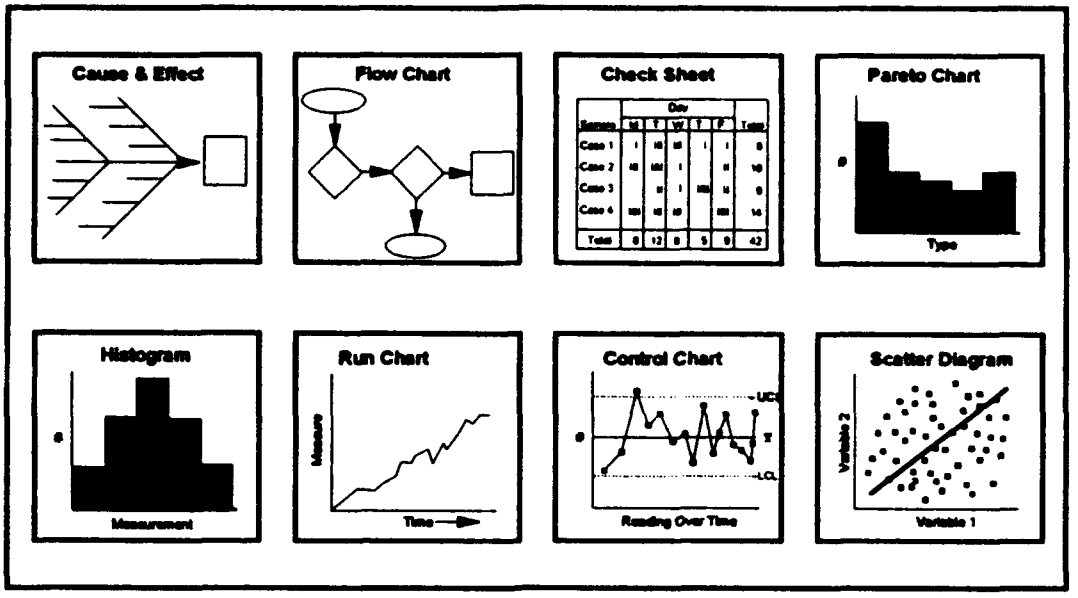


Figure 22
The Seven Quality Control Tools that, per the initial proposal, were suggested for the system. These generic tools were replaced with FACTS-specific tools in the amended Statement of Work.

In addition to the QC tools, a series of tools known as the Seven Management and Planning Tools (MP), shown in Figure 23, was also to be integrated into the Groupware System for Multidisciplinary Participation. These tools, although a powerful means of implementing steps of the management decision process, were also generic. Rather than specifically addressing the needs of the FACTS office, these tools were applicable to the full spectrum of businesses and management needs. The tools, pictured below, are applied in situations to first identify broad category issues (brainstorming), then narrow these creative ideas down to an implementable plan of action.

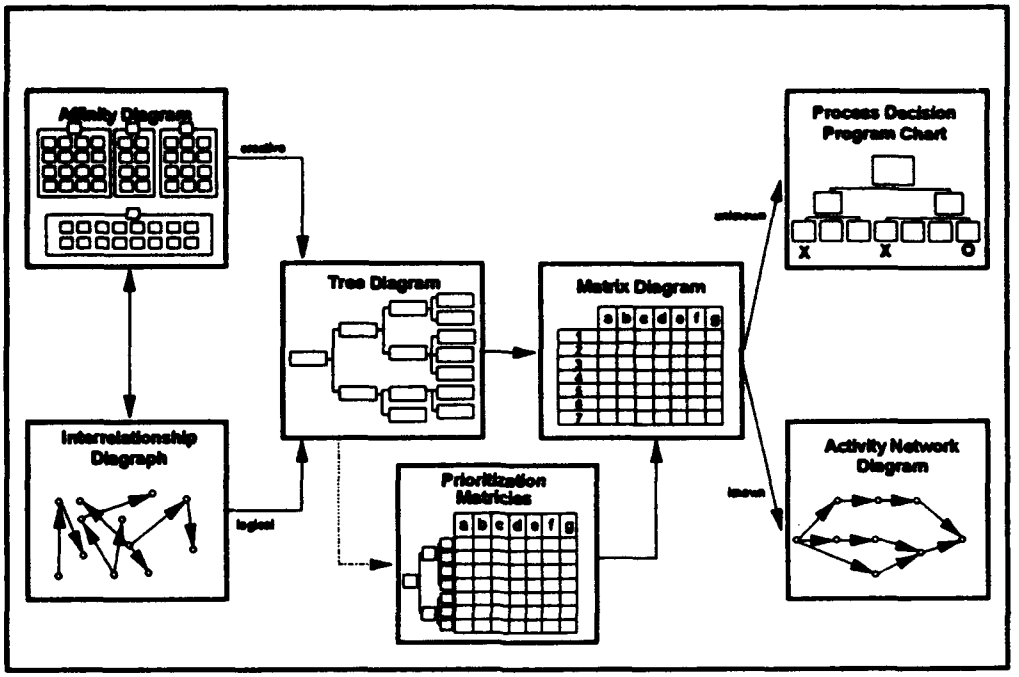


Figure 23
The Seven Management and Planning Tools, as discussed in Michael Brassard's book *The Memory Jogger Plus+*, originally planned for implementation into the SBIR system. Replaced with FACTS-specific tools in the amended Statement of Work.

Again, such generic quality tools, although useful, did not meet the needs of our newest set of FACTS customers. Rather than applying a set of generic tools to their processes, they preferred to have a set of tools developed that were specifically mapped to their standard processes and metrics.

Meeting the Changing Needs of our Small Business Innovation Research Customer

The FACTS-specific workflow module and graphical front-end required an intensive development effort that exceeded the initial Statement of Work in its comprehensiveness and applicability to the specific needs of the FACTS environment. As the workflow and GUI systems became increasingly more suited to the FACTS office, it became clear that the Tools module of the effort should not be a separate entity but, rather, should be fully integrated with the other two modules. With an integrated set of tools, Process Analysis would not be an isolated exercise, but a dynamic part of accomplishing daily tasks.

Thus, rather than develop a set of generic technologies that would go unused, QDM worked with the FACTS office to determine requirements for developing tools that would serve as an integral part of the FACTS office's business. Many of these tools were implemented into the custom Visual Basic Front-End. Others formed the basic building blocks of the workflow module. These tools, tightly integrated with the production software system, make process analysis and quality management much more than a mere intellectual exercise. The Groupware System for

Multidisciplinary Participation brings these concepts out of the realm of theory and into the practical world of everyday business. For example, not only will these tools generate metrics for abstract analysis, but they will also create the charts and graphs that must be included in the FACTS office's monthly reports.

Process Analysis/Quality Management Tools Built into the Fasteners, Actuators, Connectors, Tools, and Subsystems Graphical User Interface

The Late/On-Time button on the startup screen of the graphical Front End (as shown in Figure 24) is one powerful example of this type of practical process analysis. This button is used to generate bar charts which illustrate the number of late, on time, and impending projects. Queries can be organized by project, team, Major Command, or any combination of these factors.

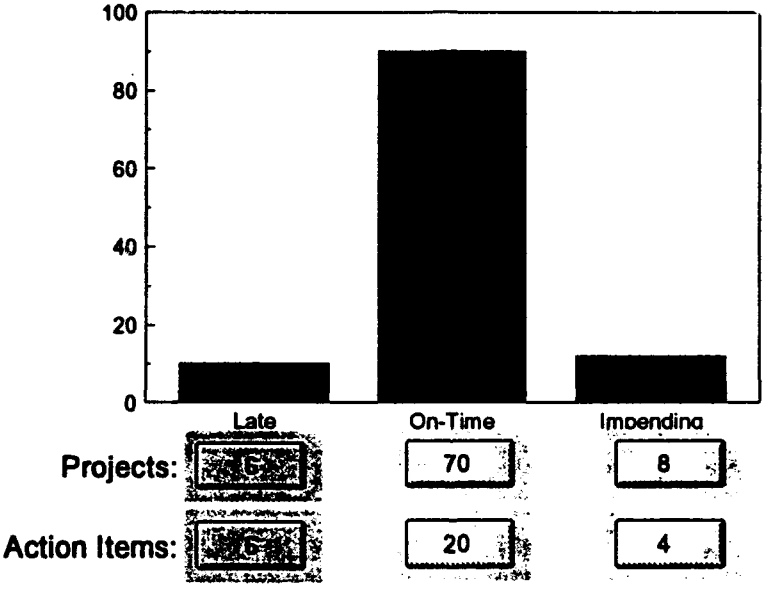


Figure 24
Sample process analysis chart generated by the FACTS-specific graphical Front-End

Additional information can be gathered to determine, for example, how late projects are, on whom progress waits, the actual schedule as against the planned and baseline schedules, and cost benefit analyses. All of these metrics and more are built into the FACTS-specific Process-Oriented Front End and are available as needed at the press of a button (See Figure 25). These tools are more specific applications of basic technologies such as the histogram, Pareto chart, and run chart generated using the relevant FACTS-specific data.

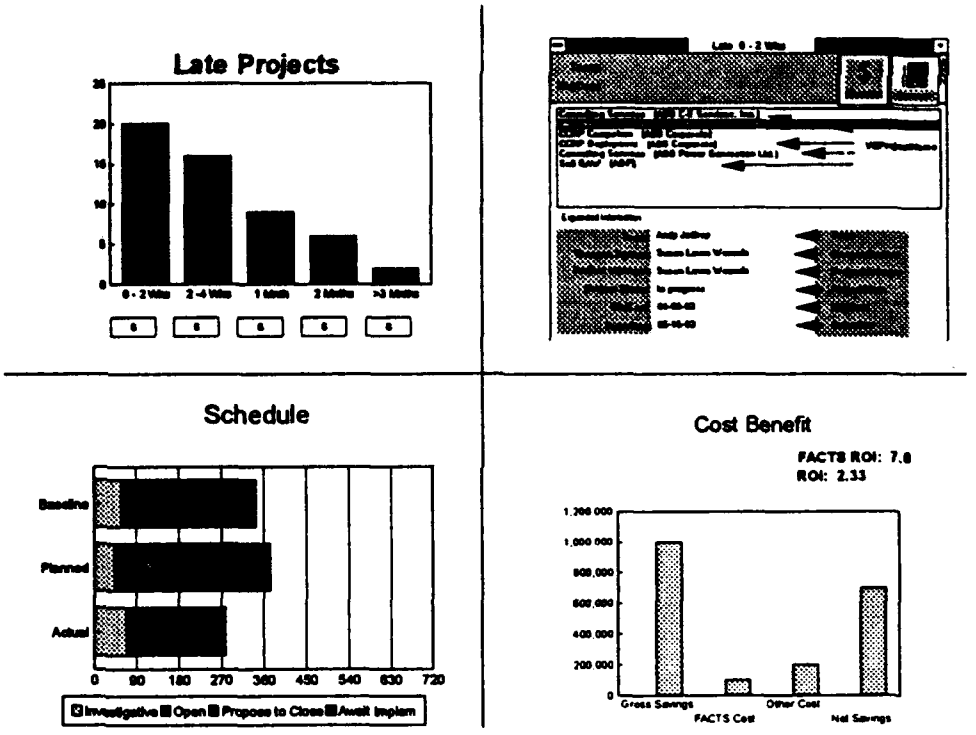


Figure 25
A sample few of the many metrics that may be graphically depicted and analyzed using the tools built into the FACTS-specific Graphical Front End

Process Analysis/Quality Management Tools Built into the Fasteners, Actuators, Connectors, Tools, and Subsystems Workflow Module

The Process Analysis metrics generated by the GUI are augmented by tools in the workflow module. For example, each user's Mail template file contains a variety of views of ongoing processes, including assignments that need the user's attention and those on which other people are currently working. Simply by opening their Mail files, users can see at a glance the status of all processes in which they are currently involved either as participants or observers (shown in Figure 26).

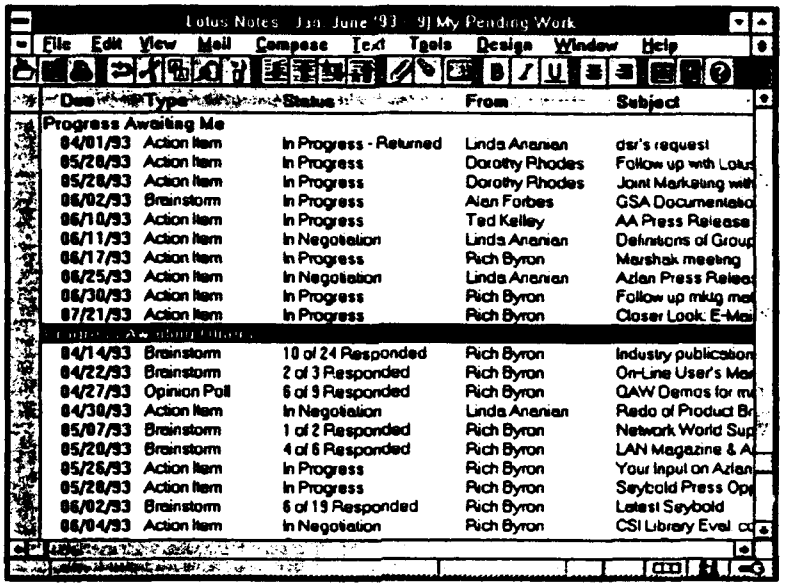


Figure 26
Example of the "My Pending Work" view that was incorporated into all FACTS Mail template files. Users may use this view to determine the status of ongoing activity and the person responsible for progress.

Other tools in the workflow module automate such QC/MP processes as brainstorming ideas, prioritizing alternatives, justifying decisions, and developing and implementing plans of action. In fact, the entire notion behind the development of **Quality *At Work*** Routing Forms was that users need simple tools to help them consistently perform common, critical tasks effectively.

For example, if users are to use tools to "identify broad category issues" as originally discussed in the initial Phase II proposal, why not give these users a powerful, easy-to-use tool that automates this process? The **Quality *At Work*** Brainstorm is a workflow-enabled form that pervades the FACTS **Quality *At Work*** system. From any Lotus Notes database within the system, a user may solicit open-ended ideas, responses, and input on any given topic. All recipients' input is collated into the original request form and returned to the sender as it comes in.

The workflow-enabled Opinion Poll form is designed to help users prioritize the alternatives that present themselves as a result of the type of Brainstorming activity discussed above. The Opinion Poll, like the Brainstorm form, travels to any number of recipients and returns their collected and collated input to the sender. The difference is that, in an Opinion Poll, the sender is asking that the recipients vote on a listed set of alternatives (perhaps the most common responses received in the Brainstorm) and add comments that support their choices. The results of the recipients' votes are automatically calculated and displayed in a table, as shown in Figure 27. All the data needed for prioritization is available at a glance.

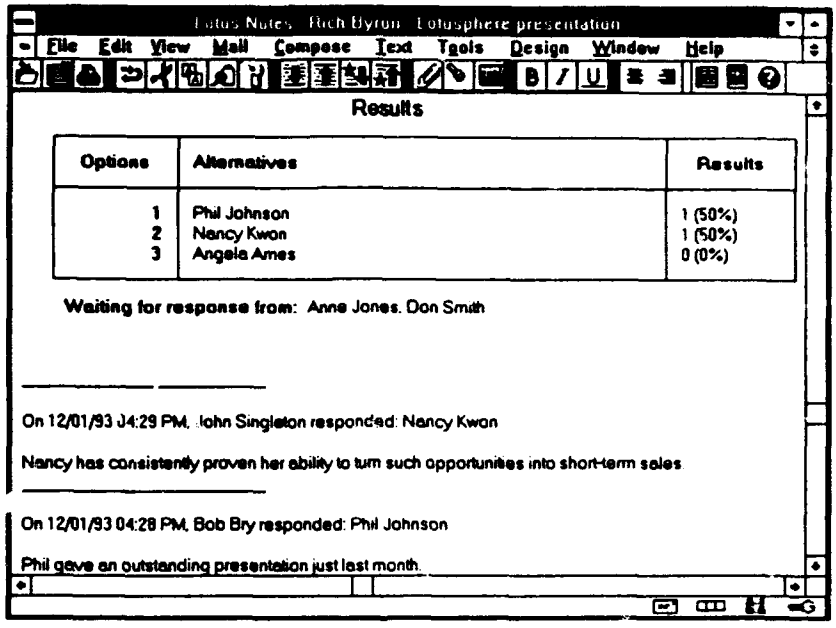


Figure 27
Results section of an Opinion Poll. The current vote tally and responses are displayed, along with the names of those recipients who have yet to respond.

Often a clear alternative emerges from the Opinion Poll results. In order to take action on this new priority, it might be necessary to build consensus about the alternative or to have it approved by a group of superiors. The **Quality *At Work*** Request Approval form automates the process of achieving sign-off from the proper parties. This form may be routed either serially to one recipient at a time or to all recipients simultaneously. Once approval is gained, implementation of a plan of action can begin.

The workflow module not only helps develop plans, it helps FACTS users act on them. The **Quality *At Work*** Action Item automates the process of delegating an ad-hoc task to a team member. The form travels between the two involved parties and is automatically updated as the task is negotiated, performed, and satisfactorily completed. For more structured, group-oriented tasks, FACTS users may use the structured production workflow tools provided in the Problem Documentation and Project databases. As discussed above, the various views in these databases and in personal Mail files are updated as the projects are worked. Pipeline views such as the one shown in Figure 28 let users of the workflow module know the current status of all ongoing activity.

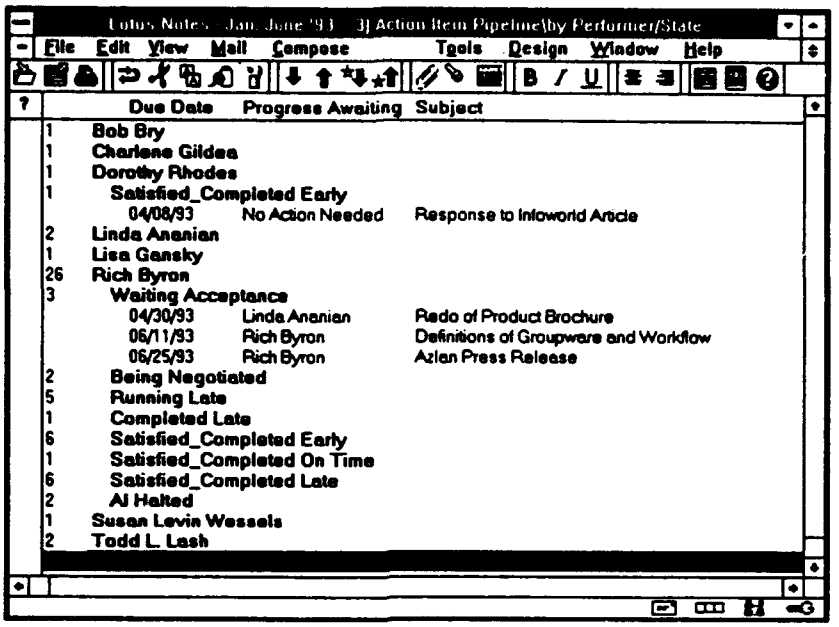


Figure 28
Pipeline view in a Mail file. Status and pending performers of all ongoing activities are displayed.

These views, fully integrated with the workflow-enabled tools enumerated above and the many metrics-based charts and graphs in the Process-Oriented Front End, help users not only analyze processes but also effectively perform them.

Use of the Technology in a Pilot Environment

The determination of a pilot site for the Groupware System for Multidisciplinary Participation was made based on the answer to the following simple question: Which candidate organization is most ready, both technically and culturally, to implement a system that will have far-reaching effects on the way work gets done? The ideal pilot environment would need three elements, a technical infrastructure, an organizational structure, and defined organizational goals, that are consistent with and support the implementation of the system. The groupware system and methodology are at the peak of their powers in an organization that possesses a willingness to change and the technological infrastructure to support that goal.

Production Workflow in the Product and Process Improvement Business Opportunities Division — Small Business Innovation Research Phase I Modification — April, 1992

During Phase I of our SBIR effort, QDM worked with the FACTS office which, through organizational realignments, became part of the Product and Process Improvement (PI) Office of CSTI. CSTI/PI was charged to manage activities to improve products and processes which would reduce operations and support costs in new and fielded weapon systems. CSTI/PI managed numerous programs in addition to FACTS to achieve this mission, including the PRAM program,

and the RAMTIP program. The cornerstone of each of these technology programs is process improvement and effective collaboration between the many DoD, Air Force (AF), and industry components that have a stake in each program. PI's goal is to maintain satisfied customers as it supports technology insertion, solves weapon system support problems, or coordinates AF and industry technology development needs.

Organizationally, this office was ideal; both the structure and the goals of the organization were completely consistent with the implementation of groupware. Its goals of continuous process and quality improvement are precisely the goals of the system itself. The fact that this office was trying to achieve and maintain these goals by managing many activities across several programs and locations makes groupware in general and Lotus Notes in particular a very powerful platform on which to develop a solution.

Recognizing this, CSTI/PI had been applying groupware to enhance its ability to work together and as the framework for cooperation and continuous improvement. It was as ready technologically as well as culturally; prior to the QDM pilot it had an existing environment of Networked Personal Computers (PCs) and was using Lotus Notes as its groupware platform. QDM developed the initial set of Lotus Notes applications used by FACTS and PI. In addition to the initial set of Lotus Notes applications, QDM's efforts at CSTI/PI produced a Business Tracking System (BTS) to provide PI with an integrated system to track, monitor, and collaborate on project and program status. The system consisted of a suite of Lotus Notes applications, integrated and monitored by an API engine developed by QDM. The primary application, the Business Tracker, provided summary status information and metrics across all PI projects in one single application, regardless of phase in the PI life cycle. The BTS represented the first step in creating an environment to monitor and improve processes across an organization.

Installing Prototype Project Management Workflow at Fasteners, Actuators, Connectors, Tools, and Subsystems — January, 1993
Training Fasteners, Actuators, Connectors, Tools, and Subsystems Office in Workflow System Use — February, 1993

Our contract monitor from AL/HRGA attended the initial beta training session on December 10 and 11 for the commercial product, **Quality *At Work***. As **Quality *At Work*** is based on the technology developed under the SBIR effort, the beta training was an opportunity to provide technology transfer and training. Beta training included an overview of the product architecture, use of the product from the end-user perspective, installation of the product, and customization of the product to a limited degree.

Up until this juncture, it was clear that the appropriate organization with which to work as a testbed was the FACTS Office. We had worked with the organization during Phase I when FACTS was a separate organization in ALD and continued to work with FACTS as it was reorganized under CSTI/PI. As we proceeded to develop the next phase of prototype technology, another reorganization occurred. The FACTS Office became a separate entity once again, moving to become part of SM, the Subsystems System Program Office (SPO). The majority of CSTI, including the former FACTS Director Col. Joseph Kruppa, were reorganized as the Technology Transition Office (TTO).

The result of this latest reorganization was two candidate test environments, both of which used Lotus Notes extensively to conduct daily business and had a strong commitment to process improvement. As FACTS had provided the funding for the effort, we decided to transition our SBIR test site to the new home for FACTS. Once again, QDM had to introduce the effort and the technology to new management in the organization; we traveled to Wright-Patterson Air Force Base (WPAFB) to do so. This latest reorganization resulted in a significant downsizing of the testbed, as we went from a commitment for an entire organization to use the technology to a small subset of the organization using the technology on a limited basis.

We worked with our Air Force point of contact to identify the Tools Team as a likely test site. Plans were made to brief the SBIR effort at the FACTS Office Staff meeting and to meet with the Tools Team to describe the next steps for their participation in the project. In addition, we established that the C-130 Air Scoop team would also participate in the test phase. This team is representative of a multidisciplinary workgroup, with members from project management, engineering, and process improvement.

Through a series of meetings held at WPAFB, we were able to coordinate the efforts of the FACTS test bed and define the specific requirements for the Tools Team prototype. We determined that we would use the FACTS Projects Folders database as the baseline and modify the existing Lotus Notes-based database to incorporate the SBIR workflow technology. We also discussed requirements to incorporate SBIR technology into the mail template files.

We explained the difference between a standard Lotus Notes database, which is just a public repository of information, and a workflow-enabled Lotus Notes database, which not only contains such public information but also interacts with user Mail files to incite action. Per the Basic Action Workflow model described previously, this action is conducted between two individuals in a closed-loop feedback system. Status updates are passed to the public database from which the assignment was generated as work is completed in user Mail files (illustrated in Figure 29).

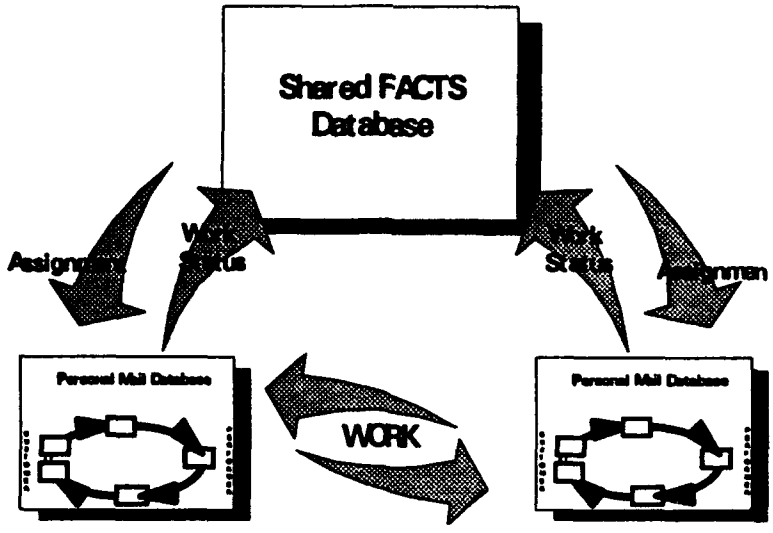


Figure 29
A workflow-enabled shared database. Work is generated and tracked in the public space as individual progress is made in private Mail files.

Prior to this effort, the FACTS Projects Folders application was a relatively straightforward Lotus Notes database that summarized details about FACTS projects and recorded progress and activity relative to the accomplishment of each project. Based on the results of our discussions, we agreed to modify the main Project Summary form to incorporate the SBIR workflow technology and to include in the databases and user Mail files the Routing Forms discussed previously in this Final Report. The SBIR technology extended the application's capabilities considerably by including the SBIR features of linked Lotus Notes databases, defined workflow-enabled business processes, and ad hoc support processes. Rather than serve as a standard Notes document, the Project Summary form became a workflow-enabled document that included such states as:

- project proposal,
- project acceptance,
- assigning project leader, and
- leader agreeing to manage project.

Training for the FACTS Tools team, C-130 Air Scoop team, and others was held on 18 February 1993 at the Groupware Laboratory at Armstrong Labs at WPAFB. The training consisted of instruction in the use of the SBIR workflow prototype software that was delivered and installed earlier in the month. A training manual, prepared by QDM, was distributed to those in attendance. Eighteen people, representing several organizations, attended the half-day intensive training. In addition to the two sponsoring organizations (FACTS Project Office — SM[illegible] — and the Acquisition Logistics Branch of the Armstrong Laboratory Logistics Research Branch — AL/HRGA), Headquarters Air Force Materiel Command (HQ AFMC), and Aeronautical Systems Center Technology Transition Division (ASC/SMT) also attended training.

The workflow-enabled version of the FACTS Project Folders database was further customized and installed on the FACTS Notes server. For the most part, the customization resulted from feedback regarding roles of team members and how the FACTS process actually worked during the training session given to the FACTS Tools team and others on 18 February 1993.

Prototype users made recommendations for changes to the system through the "QDM Feedback" form available in the Lotus Notes mailbox and the Project database. This form was automatically routed to QDM, AL/HRGA, and the Aeronautical Systems Command of the Filght Systems Engineering branch of the Subsystems System Program Office (ASC/SMEF). QDM used this form to determine whether the feedback required a change in the prototype, and whether to forward it as a recommendation to AL/HRGA and ASC/SMEF. Negotiations would be held with QDM, AL/HRGA and ASC/SMEF, if necessary. The final decision would be documented and sent to the originator of the feedback, as well as the other process participants.

Installing Prototype Graphical Front-End at the Fasteners, Actuators, Connectors, Tools, and Subsystems Office — June, 1993
Training the Fasteners, Actuators, Connectors, Tools, and Subsystems Office in Use of Graphical Front-End — June, 1993

In June 1993, we installed the Graphical User Interface module. Testing of the prototype began then and resulted in the FACTS-specific modifications discussed earlier. During the prototype installation period, we also trained the FACTS office in the administration and use of the Graphical User Interface. We trained the administrators on site. The FACTS Tools team was trained in the prototype GUI as end users. We also provided hardcopy training and installation material for the FACTS Tool Team.

Throughout this stage of the effort, we continued to respond to feedback regarding both the Front End Prototype and the Workflow Prototype in person, at our training review, and in the feedback database.

During and after the GUI training session, QDM helped answer questions and address concerns relative to the Process-Oriented Front End. Once the FACTS Tools team began to use each system, the overall tone of this feedback was one of excitement about the possibilities that such a Front End presented. However, the team began to use the system only after a seven-month delay during which little beta testing of either prototype occurred. This delay was largely due to a top-down attitude in the FACTS office that considered this SBIR effort and its technological products to be only an ancillary concern and not within the realm of mainstream business.

Despite this attitude, when the FACTS office did finally get around to testing the system, it realized that both the workflow module and the GUI could be customized to address its specific needs and integrated into a real-time management system. Feedback such as this resulted in the redirection of the SBIR effort away from the generic QC/MP tools and toward FACTS-specific installations of the workflow and GUI modules previously described.

Install and Train Users in the Use of the Fasteners, Actuators, Connectors, Tools, and Subsystems-specific Graphical Front-End at the Fasteners, Actuators, Connectors, Tools, and Subsystems Office — October-December, 1993

As a result of the test bed's request for expanded functionality, we installed and continued to test and refine the updated Workflow and Graphical User Interface modules at the test bed. The enhancement of these portions of the technology grew as a result of the FACTS request for more robust production technology that has been tailored to address specific business situations. We are providing FACTS with technology that will continue to evolve as its business requirements continue to evolve.

We are providing informal administration training (technical transfer-type training) as we install the enhanced portions of the effort. End user training has been previously provided; any further end user training can be incorporated with basic Lotus Notes training. The contract modification was entirely a technical development effort and did not provide for additional training.

The Path to a Better System

Throughout the development of the Groupware System for Multidisciplinary Participation, QDM has learned much and has applied these lessons to the process of improving and refining the system. Critical decisions such as the definition of the methodology for teamwork, the selection of the groupware platform and workflow system in which to implement this methodology, the integration of the tools module into the process analysis capabilities of the workflow system and GUI, and the determination of an appropriate pilot environment in which to test the system all had a great deal of impact on the development and maturation of the system and the SBIR effort as a whole. The results of each of these decisions are discussed in the next section of this Final Report.

DISCUSSION OF RESULTS

This Phase II SBIR effort has resulted in the creation of innovative new technologies and in the application and integration of emerging and existing technologies in powerful new ways. While these results are exciting from a technological standpoint, the real gains have been on the human side. People are now working together in ways never before possible, and knowledge and expertise can be contributed and shared throughout the organization. Activity can be tracked and monitored at all levels, from personal productivity to organization-wide executive-level views. Geographical and interdepartmental barriers to communication and teamwork have been effectively eliminated.

These gains would not have been possible if not for QDM's realization that technology cannot drive the organization. Phase II of this SBIR effort has clearly demonstrated the importance of a synergistic relationship between an organization's culture and technology. Just as the culture can be influenced by the effective introduction and use of groupware, workflow, and process analysis tools, so can the design and implementation of the technology be driven by the needs, desires, and work habits of the culture.

One of the difficulties in discussing the results of a groupware system is that some of the positive effects that are achieved are not easily measured. Ronni Marshak, a respected industry analyst, in her recent article "What is Productivity, Anyway?," discusses the difficulty of initially quantifying the results of a successfully implemented groupware system. She proposes the following approach to gauging results: "Rather than measuring the *amount* of work that can get done, I think we should measure the *quality* of the work that gets done" (Marshak, 1993).

Marshak uses the analogy of word processing software to make her point. Word processors do not make people faster typists, but they make editing and reprinting much faster, and they greatly improve the quality of the finished product. It is no longer acceptable to submit a proposal that has correction fluid applied over its typographical errors. Marshak predicts similar results from the advent of groupware: "I believe that there will be similar improvement in the quality of group work. Actually, the improved quality could be even greater — after all, the whole is greater than the sum of its parts. Productive individuals working together should result in even more productive groups" (Marshak, 1993).

However, as we pointed out in our initial, critical assertion, these benefits are not automatic. They are a product of two equally important factors: a responsive, well-designed system, and an effective, culturally-sensitive implementation of that system. If a group-oriented technology, regardless of its level of technical sophistication, runs counter to the culture and goals of the organization, it is destined to fail.

The following sections will detail the results of our efforts and decisions during the design, creation, and implementation of the Groupware System for Multidisciplinary Participation, as depicted in Figure 30. These results are powerful technological, methodological, and cultural lessons that have provided concrete benefits to both our SBIR and our commercial efforts in the past and will continue to do so into the future.

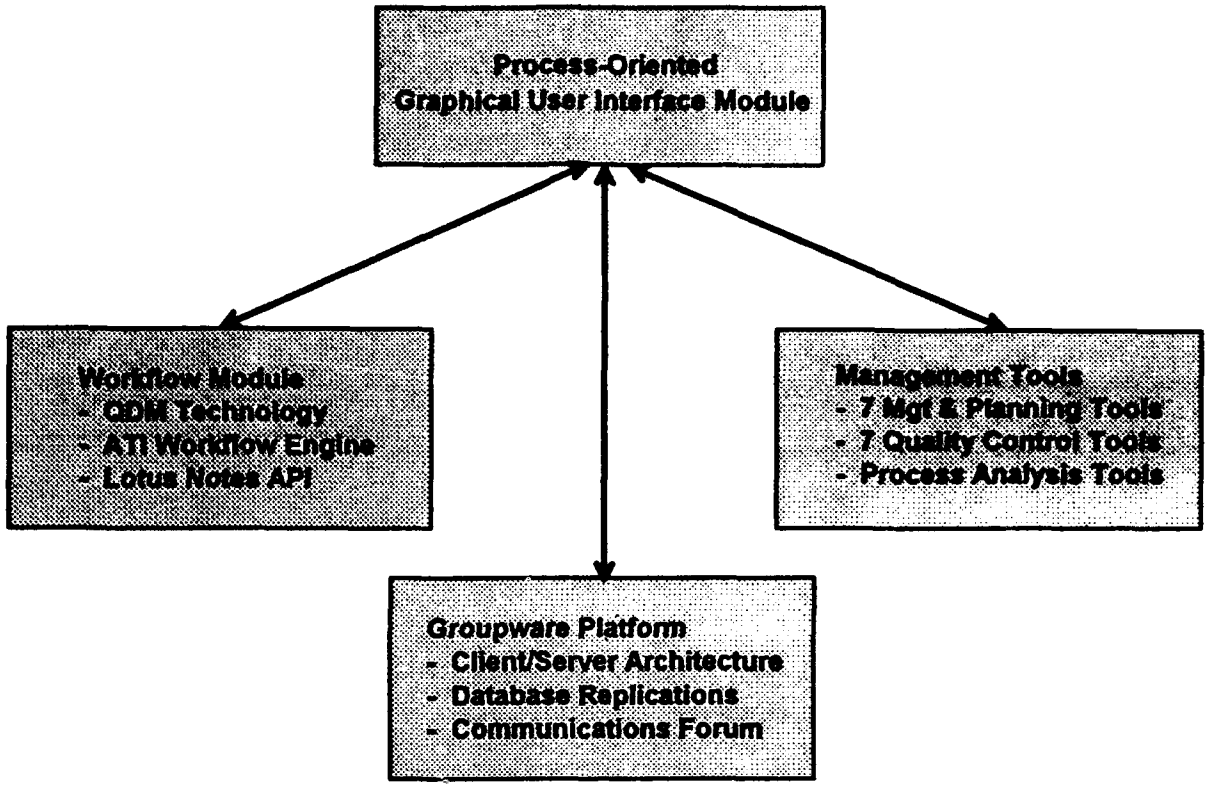


Figure 30
The Groupware System for Multidisciplinary Participation developed in a series of interconnected modules. Results were achieved and lessons learned from each individual module as well as the system as a whole.

MODULAR ARCHITECTURE OF THE SBIR SYSTEM

The Selection of Lotus Notes as the Groupware Platform

As explained earlier, QDM selected Lotus Notes as the groupware platform on which to develop the System for Multidisciplinary Participation. This selection was made a few short months after Lotus Notes had first been released in late 1989, and was based on QDM's assessment that Lotus Notes' features and architecture would provide all the technological components for our robust system's architecture.

Four years later, the rest of the software industry and end-user community is realizing what QDM had accurately deduced from the beginning. Lotus Notes is now the standard against which all other groupware platforms will be measured. Indeed, Lotus Notes is so far ahead of the field as to have no direct competition at this writing. No other product can match Lotus Notes' features and flexibility as a groupware application development platform.

The FACTS office is now one of the many organizations across the globe that is realizing direct benefits from the use of the Lotus Notes platform. Effective Notes applications, especially workflow-enabled ones such as **Quality *At Work***, are enabling individuals and workgroups at

FACTS and throughout the private sector to communicate and share information in ways never before possible. Lotus Notes' unique public spaces encourage and enable organizational-wide input, allowing more people to apply and share their expertise across a wider range of projects. Rather than work in a vacuum of personal responsibility, users are empowered with the ability to peruse the activities of the entire organization and contribute their expertise to all appropriate processes. By providing such capabilities as these, Lotus Notes is steadily redefining and extending the definition and benefits of teamwork.

Lotus' competitors, such industry giants as Microsoft and Oracle, are scrambling to come up with an answer for the Lotus Notes phenomenon. They realize that Lotus Notes' power as a communication and teamwork platform has enabled it to continue to dominate the market it has defined.

Workflow Lessons Learned: Technological Tools for Culture-Defined Needs

Designing and implementing workflow solutions during this SBIR effort has led us to some revelations about what this technology is and how best it can be used. Through lessons learned during this SBIR effort, QDM has broadened the entire concept of workflow and discovered the best ways of applying it.

A Spectrum of Solutions

When QDM first began working with workflow, the technology was young, and the concept behind it was quite specific. The spectrum of workflow solutions at this time consisted of a single point: production workflow. "Workflow" in the technological sense had only one meaning: the software automation of a sequence of predefined steps

Implementing this type of workflow in our SBIR pilot environments illustrated to us both the power and limitations of this technology. While production workflow proved extremely useful in performing its intended function, a technological void existed in automating processes that were less structured or more loosely defined. QDM invented ad-hoc workflow tools to fill this need and, in so doing, broadened the definition of "workflow" to include a spectrum of solutions that is now capable of automating every type of process, from the most complex, rigidly defined process to the most basic, elemental ad-hoc functions that pervade daily business.

Our SBIR efforts have also taught us the basic lesson that the type of workflow introduced into an organization must match the type of process it is automating. Further, and at an even more elemental level, we have learned that the nature of an organization's processes (e.g., the degree of flexibility and variation required to accommodate the culture of the organization) is directly driven by the nature of the organization itself. Thus, the first step and primary factor in determining a suitable workflow solution for an organization is to examine the organization itself.

Striking a Cultural Nerve with Workflow

Because workflow is mapped so closely to processes, and processes mapped so closely to organizational culture, the selection and implementation of a workflow system has an immediate and powerful cultural impact. If this impact is generally positive, an organization can expect large improvements in the areas of operations and productivity. A negative initial reaction could result in wholesale rejection of the technology, and the effort that went into designing and implementing it would be wasted. Given these stakes, it is vital to determine an organization's cultural needs and preferences prior to designing a system that supports them.

Our SBIR pilots, as we will discuss in detail later in this section, taught us many of these lessons. Implementing a production workflow system in an environment that was not ready for it (namely, PIBO) resulted in some of the unpleasant ramifications discussed above. These consequences do not constitute an indictment of the PIBO organization; they merely indicate that the type of workflow selected for the system did not accurately reflect the culture of the organization at that time. PIBO was in a state of flux during this period; it was constantly being redefined by organizational realignments within the Air Force. These cultural factors made the complex PIBO process much more subject to change than it might have been otherwise and, thus, made the production workflow system unduly restrictive in this environment. This clash between culture and technology proved to be a valuable lesson for QDM in the design of future pilot and commercial systems.

As a result of the incompatibility of this type of workflow with the organization's culture, and because the system arrived just as the organization was being realigned, we found that the custom solution that we delivered to PIBO was rarely used. The automation that was relevant to the PRAM, RAMTIP, and FACTS offices became less so when those organizations were separated into different commanding divisions.

A Common Denominator

Despite the difficulties with our initial production workflow pilot, we learned many valuable lessons. Perhaps the most important of these was that the users of the PIBO production system did not reject the individual actions in the workflow so much as the forced sequence of these actions. In fact, the sequence of events was the only factor that was continually changing as a result of organizational realignments. The individual elements of the process remained relevant to the task of getting the work done. When we distilled the larger process down into its components, we noticed a few common processes that not only continually occurred within PIBO, but seemed relevant and pervasive in business in general. Such processes as assigning action, gathering input, building consensus, and gaining approval became the building blocks for ad-hoc workflow tools.

Based on our observations of and feedback from the PIBO pilot, we determined that de-coupling these processes from the structure of production workflow sequencing would provide a powerful set of basic workflow tools. Mapping these processes to the Basic Action Workflow was the next logical step. All of these processes naturally followed the closed-loop feedback form of conversation as described by the ATI diagram (see Fig. 7). Our SBIR effort had taught us the

vital lesson that, in order for workflow technology to work effectively, it had not only to automate and streamline processes but to do so in a manner that users would be willing and eager to use.

These ad-hoc tools filled the basic needs of organizations looking to automate and streamline their most elemental processes. The tools complement a production workflow environment well: they can be used on an as-needed basis when situations arise in the course of daily business. Selectively applying these tools lets users build complex processes based not on a pre-defined set of rules and conditions, but on the specific, highly fluid demands of a dynamic workplace. As users' needs change, they may select and apply the tools or combinations of tools that will allow them to achieve the desired results (as shown in Figure 31.)

Forms-Based, Ad-Hoc Workflow

These tools, when added to the baseline workflow system, increase both the functionality and the potential palatability of the system. These tools form the nucleus of the commercial product, **Quality *At Work***, that resulted directly from technologies developed as part of this SBIR effort. As mentioned, these technologies are to a large extent the products of lessons learned from our earliest pilots. The initial user rejection of the production workflow system at PIBO gave us insights into the types of technologies that would work in this environment.

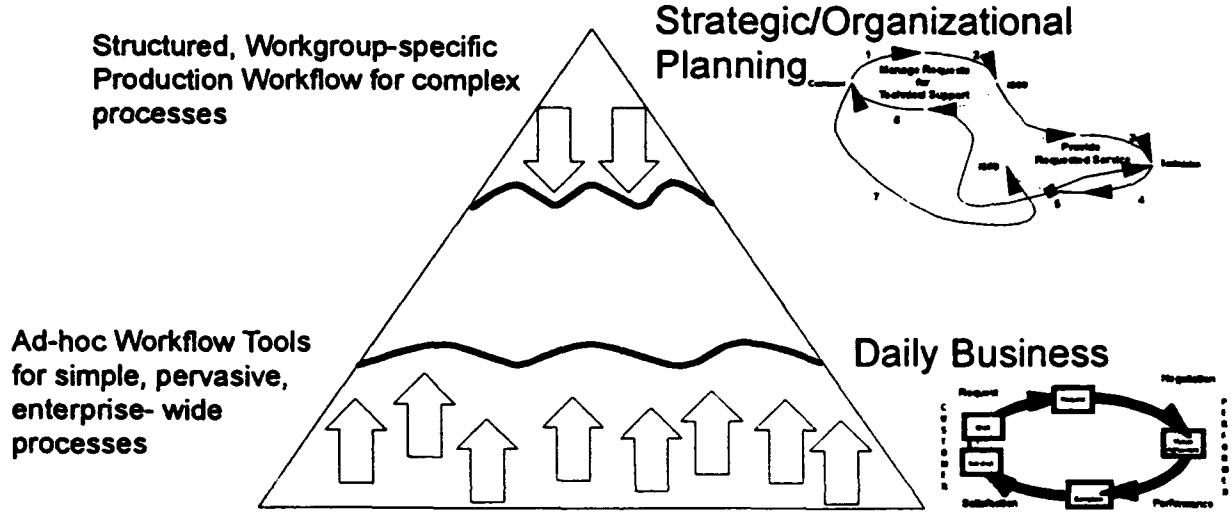


Figure 31
Ad-hoc tools complement a production workflow environment by automating the types of common processes critical to the accomplishment of larger objectives, but difficult to fully anticipate.

Providing tools to users, rather than structuring and automating a rigid process, smoothes the transition to the workflow-enabled system and culture. Users will use the tools as they see fit, applying the system to the ever-changing challenges of daily business. For more fluid processes, this plan is much more culturally palatable than the strict recipe mandated by production

workflow. These ad-hoc tools were designed and rolled out in a much more culturally seamless fashion in the FACTS office and, as a result, were much more widely accepted.

In the workflow domain, these simple, powerful tools represent and automate ad-hoc and administrative processes. For instance, the act of asking an associate to do a simple task is one of the most basic, pervasive transactions in the business world. A tool (such as the QAW Action Item) which automates and monitors the assignment, progress, and successful completion of such ad-hoc activities could be effectively applied to the full spectrum of business concerns.

Similarly, tools such as the **Quality *At Work*** Brainstorm, Opinion Poll, and Request Approval represent and embody common ad-hoc and administrative practices — soliciting ideas and input, building consensus, and gaining the approval of superiors — that occur across a broad range of organizations. These tools, together with the Action Item, are the basic building blocks with which individuals may construct more complex processes. QDM actively encourages users to do so by making each tool so simple and powerful.

Consistent with QDM's definition of Management Technology, these technological tools embody and seamlessly implement effective business practices into the workplace. Because these practices take the form of simple workflow tools that are used daily, they "come in under the cultural radar system" of the organization. Merely by giving people simple, powerful tools with which to perform their work, an organization may implement "best practices."

Forms-based Workflow in the Fasteners, Actuators, Connectors, Tools, and Subsystems (FACTS) Office

Based on lessons learned during our production workflow experience at PIBO, we concentrated our efforts on a forms-based workflow solution for the FACTS office because we recognized that their dynamic culture would demand such flexible tools. We eliminated the restrictive aspects of the technology and successfully installed a forms-based solution. As discussed earlier, these forms-based tools gave users additional flexibility and made no strict demands about how they should be used.

We assumed that, because these tools were more suited to their environment and, thus, more culturally palatable, this new system would be more easily accepted and widely used. However, we soon discovered that even this flexible system was not being satisfactorily embraced by the user community. Other cultural factors were not being sufficiently addressed in the FACTS office, preventing the pilot from reaching critical mass and gaining momentum and acceptance.

One of the most powerful factors in this lack of momentum was the instability at the top of the FACTS office; it is now working under its fourth colonel since the beginning of the effort. Because of these frequent shifts in leadership, QDM was unable to establish a consistent level of management commitment in the technology.

This instability was exacerbated by a lack of training and awareness in workgroup processes. If team members are not fully aware of business processes, it is more difficult to realize the benefits

of a workflow system. Users who are not fully aware of how a process works are much less likely to notice and appreciate improvements in the way that process is performed.

A driving factor in this lack of process awareness was the amount of turnaround in the FACTS office, not just at the management level, but throughout the organization. Technical and support staff members came and went, creating inconsistencies at all levels and continually restocking the organization with personnel who were unfamiliar with its culture, processes, and tools.

Recently, under its current leadership, the FACTS office began to use the pilot system in earnest and realized the extent to which these technologies could be highly useful. Both the workflow system and the Process-Oriented Front End were recognized as tools which could streamline operations and increase individual and workgroup productivity. Users were made aware of the degree to which FACTS-specific processes could be mapped to these technologies, and with this awareness came the opportunity for the culture of the FACTS office to drive the design of the groupware system.

Real, practical needs drove the design of the system and ensured its current and future applicability. The Groupware System for Multidisciplinary Participation is currently in use in the FACTS office, helping manage projects, keep commitments, and generate the metrics needed to produce monthly status reports. In addition to streamlining operations, the system now allows FACTS to capture and examine records of past performance and to build future successes on the lessons learned from these records.

By modeling the system after the culture, QDM and the FACTS office have worked together to ensure that the SBIR technology is implemented into a system that is liked and used by the community. Building this system with flexible tools as opposed to hard-coded, strictly defined processes ensures that it will remain relevant in the future.

Ad-hoc Tools: A Smart First Step to a Workflow-Enabled Culture

The "toolbox" approach also helps ensure the solution will remain responsive to the needs of individuals and workgroups. Because these tools are simple and easy to use, they may be added to or removed from the toolbox as necessary. Users have the power to dictate the relative importance of each tool merely by using it.

This implementation also allows for the inevitable variations, however slight, in the ways that different workgroups perform similar tasks. The fact that two workgroups perform a similar task slightly differently is not an indictment in itself — it is merely an indication that each is remaining sensitive to the dynamics at work in the group and the highly specific sets of circumstances that dictate proper action. These variations speak volumes about the way that an organization achieves its business goals and, for that reason, are worth capturing and examining.

Such variation does not rule out a structured production workflow system. In fact, analyzing strings of ad-hoc processes can lead to the effective design and implementation of a production workflow system. In many cases, a workflow toolbox can be a smart first step on the path to production workflow by helping an organization automate processes based on past successes, not on ethereal analyses.

A critical factor when analyzing user patterns should be the degree of variation between workgroups. The way different workgroups apply similar tools to similar tasks could be the key to the continued success of the systems solution. Figure 32 depicts two possible patterns of use that might develop in a "workflow toolbox" environment.

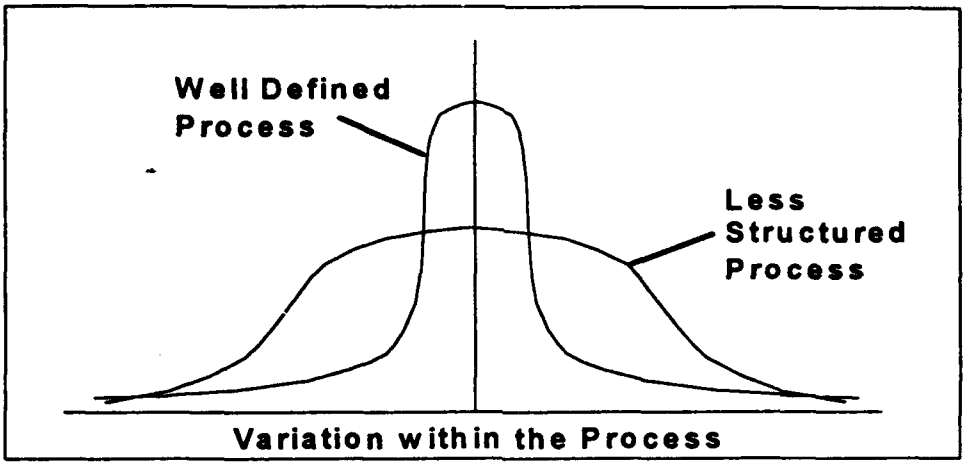


Figure 32
Graph displaying two possible degrees of variation in the way different workgroups perform similar processes. Little variation (top curve) indicates a possible candidate environment for a strict production workflow system, while more variation (bottom curve) demonstrates the continued need for ad-hoc tools.

If little variation is noticed in the way different workgroups perform a given process (as illustrated in the top curve), it might be best for the organization to fully automate that process by locking in to a structured production workflow system. If past experience proves that the steps involved are rigidly defined across the full bandwidth of users and not prone to change, a custom production workflow solution would effectively process the flow of work along these structured lines. The organization will have chosen production workflow as a result of observed past patterns of success, not as a result of expensive, ethereal analysis and process design. In combination with production workflow systems, the workflow toolbox will fill the ad-hoc gaps in the process, nicely complementing the predefined aspects of the process.

If, on the other hand, a fair amount of variation is noticed in the way different workgroups use the tools, (as in the bottom, flatter curve) production workflow would have the damaging effect of forcing all workgroups to conform to one given work pattern. The fact that different workgroups are not performing a given process in precisely the same way every time does not mean that each workgroup is not acting efficiently and effectively. Indeed, in today's dynamic business environments, concrete, structured "standard procedures" are much more the exception than the rule.

Examining past practices can also lead to the continued refinement of the toolbox to ensure that it remains maximally useful. Corporate management and MIS can observe patterns of use among and between user workgroups to ensure that the system is effectively responding to the needs of the users. As these patterns continue to emerge and develop, the toolbox can be expanded and

tailored so that the workflow solution continues to meet the demands of the users and business situations into the future. For example, if a group is constantly using Action Items to request that parts be shipped to a client site, a customized "Send Materials" form can be easily created from the baseline Action Item. The users dictate the design of the technology, rather than the technology dictating the work habits of the users.

All of these workflow and groupware "lessons learned" were instrumental in the design and release of the commercial software product **Quality *At Work***. Just one year into this effort, QDM was able to apply the technology we developed and the knowledge we gained to the successful launch of a commercial software product. **Quality *At Work*** is currently in use worldwide by businesses and organizations of all sizes, including a Global 50 conglomerate (Asea Brown Boveri or ABB), a world renowned consulting firm (Arthur Andersen), and a large Government agency (GSA). This widespread applicability is consistent with, and validation of, our assertions in our initial proposal as to the commercial viability of these technologies.

Graphical User Interface/Process Analysis Tools

The design of the process analysis tools and the Graphical Front-End into which they were built was similarly user-driven. This development effort resulted at first in a flexible, generic Front End and then, based on positive feedback and interest, in a powerful tool that our SBIR customer is using not only to analyze its processes but also to streamline the creation of PMR Reports. The SBIR technology is being used not in a sterile test environment, but in the rigorous course of daily business to help management-level personnel get their jobs done.

Here again, the focus of the development effort was not on the technology but on the business need that the technology could address. In this instance, the specific need was for a tool that would provide a management-level summary of data collected from the workflow module. Lotus Notes itself could not adequately collect and graphically display data across the entire spectrum of the workflow module; we needed a separate development environment.

Our search for an appropriate development environment for the Graphical Front End is testimony to the fact that the scope of business solutions is limited, not by the technology available, but by the intelligence with which the technology is applied. When the Notebook environment proved unsuitable for the GUI effort, numerous other candidate environments were available. QDM had only to explore these alternatives and settle on the most appropriate tool. There was and is plenty of available technology with which to craft powerful business solutions, but it is impossible to do so without a thorough understanding of the culture and goals of the organization.

This understanding of the needs and goals led to the redirection of the remainder of the SBIR effort. As discussed, the FACTS office, upon using the prototype GUI and realizing its power and potential, asked that we customize the prototype to reflect FACTS-specific metrics. QDM's consistent attention to the changing needs of our SBIR customer resulted in the custom-fit solution that is detailed at length earlier in this report. The FACTS office, by providing feedback throughout the process, received a solution that displays precisely the graphs and metrics that the office needs and uses. The Front End, now that it embodies and displays FACTS-specific

processes from the perspective of FACTS-specific metrics, has gained office-wide acceptance as a powerful, useful technological tool.

CONCLUDING REMARKS

QDM's critical assertion upon entering this Phase II effort was that technology cannot drive an organization — it must be sensitive and responsive to the culture, needs, and goals of the organization. This assertion affects every aspect of the implementation of technology into the workplace, from the initial design of the system to the way it is introduced to its end users. Three crucial, interrelated factors govern the successful roll-out of any technology within an organization. They are as follow.

- An Understanding of the Culture of the Organization
- A Technology Designed to Reflect and Support this Culture
- An Effective Introduction/Implementation into the Workplace

Over the course of this SBIR effort, and through the release of the commercial software product that resulted from the SBIR technology (**Quality *At Work***), QDM has refined its knowledge of each of these factors. We have not only invented groundbreaking technology; we have discovered the best ways to introduce this technology such that its full power and potential is realized by the user community. We now know not only what makes a system design intelligent, but also what makes technology culturally palatable and what makes an implementation scheme effective.

Understanding the Culture of the Organization

In order to select the proper workflow system for an organization, it is critical to understand the nature of its processes. However, as we have stated previously, it is not possible to gain a full understanding and appreciation of an organization's processes without first studying the organization itself. The culture of the organization defines the nature of its processes. Thus, the first step in selecting a workflow solution for an organization is to classify the culture of the organization on the "spectrum of flexibility," as illustrated in Figure 33.

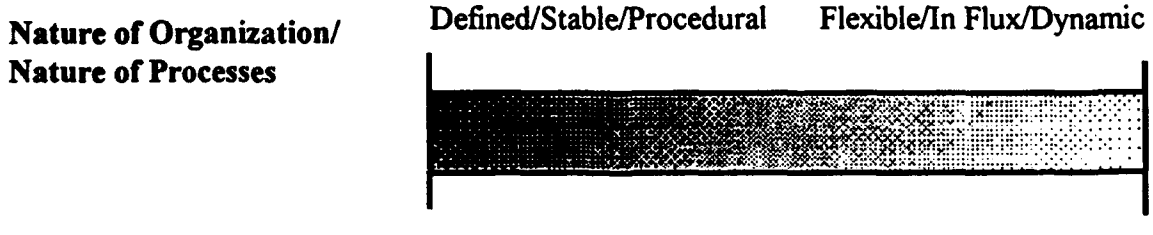


Figure 33
The "spectrum of flexibility"

An organization's location on this spectrum is a product of a combination of factors: management styles, personalities of personnel, awareness of processes, the percentage of work performed by "knowledge workers" (e.g. the degree to which ad-hoc decision making affects the process. Is the emphasis on input or throughput?), and external trends such as the prevailing business climate or industry trends. As these factors change over time, the organization's location on the spectrum will adjust accordingly. For example, a commercial bank is ordinarily a very stable, procedural organization. Standard practices are generally established and managers and team members alike are comfortable with following them, because these practices are well known and represent the best way to get the job done. However, during the turbulent economic climate of the 1980s, many banks were in a state of flux because of potential mergers, fluctuating rates, and other similar situations. These external factors pushed these banks closer to the right end of the spectrum.

In addition to the flexibility factor, intelligent system design also involves simplicity and ease of use; a system cannot be effective if it is a burden to learn and use. Well-designed production systems will route forms and advance processes with minimal effort from the user. Effective ad-hoc tools should pervade the system and be as user-friendly as a standard electronic-mail Memo. A Graphical User Interface must capture the metrics most relevant to a business and display them in colorful, user-friendly charts. Browsing through a business' processes and shifting level of focus should be as simple as clicking a button.

Mapping the Technology to the Culture

Technology should reflect and support the culture of the organization into which it is being implemented. With workflow solutions, mapping the technology to the culture is relatively simple, because the nature and goals of the spectrum of workflow systems runs parallel to the "spectrum of flexibility" of organizations (see Figure 34). More stable, rigid organizations tend to have more static processes that are best automated by production workflow. Ad-hoc tools in these organizations are used to "plug the gaps" in the production process. More flexible organizations profit most from the exclusive use of ad-hoc workflow tools.

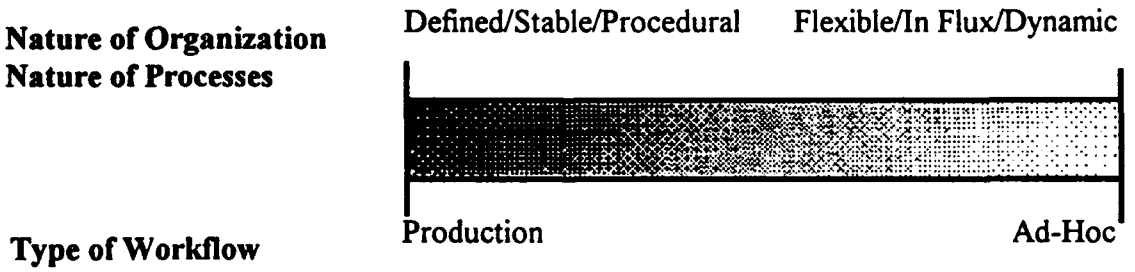


Figure 34
The "spectrum of flexibility" from Production to Ad-hoc Workflow

For organizations and processes that are very procedural and involve a defined series of steps, production workflow could provide a significant return on investment. However, our SBIR effort and pilots have demonstrated that the integration of ad-hoc workflow tools as an introduction or

complement to production systems can ease the transition to production workflow. These more flexible, easy-to-use tools can introduce and complement production workflow effectively. First, ad-hoc tools can be implemented as a smart first step to a production workflow process. They are easy to use, and they pervade the organization, thus seamlessly acclimating the users and culture to the concept of workflow. Second, after the tools are introduced, the ways in which the tools are applied by users can be captured and analyzed, and the processes that have proven most successful with the least amount of user variation in their performance (see Figure 32) can be automated with production workflow. Finally, once the production workflow process is in place, the ad-hoc tools can continue to complement it by streamlining the unanticipated daily processes that occur in support of the larger process.

This evolutionary paradigm provides cultural benefits in addition to technological flexibility. QDM has learned that users often resist the advent of workflow systems whose position on the workflow spectrum does not match the organization's standing on the "spectrum of flexibility." Inappropriate levels of structure (or, for that matter, flexibility) create user and management resistance to the technology and could lead to rejection of the system. Fitting the technology over the organization's culture and processes is more palatable and, thus, more likely to be successful than forcing the culture and processes into the technology.

For this reason, QDM has developed a custom toolbox full of simple, powerful, easy-to-use tools that can be selectively applied and strung together to meet specific needs as situations arise in the course of business. With these tools, users will build processes naturally. Rather than defining the process and having users conform to it per the production workflow paradigm, this "toolbox" approach lets users use simple, powerful tools to construct complex processes based on their own specific work patterns. As these processes become more common, the organization will naturally slide toward the left side of the spectrum, and, thus, production workflow will be an increasingly viable option for those processes.

Because the Graphical User Interface is so tightly integrated with the workflow module, these patterns are easily recognized and digested by the user community through charts and graphs. Using this piece of technology, users can continue to refine the workflow module to ensure that their organization, processes, and workflow solution remain synchronized on the spectrum.

An Effective Implementation Scheme

Matching the technology to the organization is critical, but even doing so perfectly does not guarantee success. Even the best-designed, most culturally seamless application can still fall flat if it is forced upon users against their will. Achieving management commitment and user buy-in is absolutely essential to the successful roll-out of groupware technology, especially across multidisciplinary workgroups and cross-functional teams. The technology or product alone is not enough to win the battle. Success in the business and cultural context comes from providing the necessary system integration, planning, installation, training, and support components to augment the technology as "whole product."

Our experiences with our various pilot environments throughout the SBIR effort have illustrated to us the issues that must be considered in a successful implementation. Having identified these

issues, we devised strategies for anticipating and eliminating them as possible barriers to a seamless roll-out.

Clear Cultural Hurdles

The results of our pilots have demonstrated to us that the most critical factors in the successful implementation of a groupware solution, especially one involving workflow technology, are cultural in nature. The single most important of these factors is user buy-in. Of course, the most effective path to follow to this end is the path of least resistance. This path involves engaging and enabling users with powerful, flexible tools, not mandating a standard way of doing things.

Our implementations of commercial workflow-enabled groupware products at the Government's GSA have demonstrated to us the paths of least resistance both in design and implementation of these systems. A production workflow Helpdesk system was forced upon technicians and support staff in the agency and, as a result, was met with widespread resistance. A quality initiative, on the other hand, was pursued with a combination production/ad-hoc workflow system. The system was introduced to users in a dynamic, interactive training session involving simulation and role-playing. As a result, the user community embraced both the system and the quality initiative that it supported.

Train for Success

First impressions are powerful, and initial user rejection is extremely difficult to overcome. The first inroads into engaging the users can be made during training sessions. Training in multidisciplinary groupware systems should focus not on the dry mechanics of using the system but, rather, on the most effective ways of applying the environment and the system's tools to the challenges of daily business.

Based on our success at the GSA, QDM has developed a unique approach to training for groupware applications that provides a seamless transition to the environment. Rather than outlining the mechanics of using the application, the training focuses on how to weave the tools into daily practice. Simulation and role-playing are used (the "murder mystery approach") to teach users to apply the tools to business situations.

From these training exercises comes an awareness of and appreciation for workgroup interaction and the dynamics of group collaboration and coordination. Building awareness of these processes from the outset will foster the acceptance of the system as an ally in these efforts, not an inhibitor of them.

Identify and Target the Champion

This acceptance is further fostered by an internal product champion who has the vision and leadership to realize the power of the groupware environment and the skill to choose and implement a solution with it. A champion who is enthusiastic about the technology can be a powerful force for change within an organization. We witnessed firsthand the importance of a champion in our experiences with the FACTS office.

Colonel (Ret.) Robert Rissell, who initially sponsored this SBIR effort and who "founded" the FACTS office, was a true visionary who believed wholeheartedly in the power of these technologies and their applicability to business situations. His efforts were instrumental in getting this SBIR project funded and off the ground, and his diligence and vision have been rewarded with a SBIR project that warranted an "SBIR Success Story" and resulted in a highly successful commercial software product.

Colonel Joseph N. Kruppa shared Rissell's vision and enthusiasm and took all necessary steps to ensure that the effort continued to move forward. Under the leadership of these two colonels, this SBIR effort flourished. Lt. Col. Sammy Saliba has also been instrumental in lending focus and direction to this SBIR effort and the system it produced. His process needs defined the types of metrics that would be displayed by the GUI to ensure that the system would be and remain maximally useful to the FACTS office.

RECOMMENDATIONS

QDM's belief that process improvement can only be achieved through process awareness has been consistently reinforced throughout this SBIR effort. Our research has illustrated to us that improving the ways people work together is a complex process that involves the synergy of technological and methodological concepts, while at the same time uncovering knowledge that has helped us understand and tackle this complexity.

The knowledge that QDM has gained during this SBIR effort has enabled us to stratify the issues at stake in designing an effective Groupware System for Multidisciplinary Participation. We now recognize the strength of the bond between an organization's place on the "spectrum of flexibility" and the type of workflow solution that will work best for that organization. These lessons were incorporated into a system that both satisfied this SBIR contract and, through QDM's extensive effort independent of the SBIR grant, was successfully commercialized.

Recommendation: Realize Potential of Small Business Innovation Research (SBIR) Investment

The demonstrated commercial success of the product proves that companies in the private sector recognize the benefits of this technology and achieve them by using it. These same benefits are attainable by government organizations, the natural beneficiaries of a successful SBIR program.

These organizations can now realize these benefits with a minimal investment and at almost no risk. The technology that makes teamwork possible and easy can and should be widely applied throughout the government. This flexible, powerful technology is now, thanks to the SBIR program, fully developed. The opportunities for applying it within the Government are unlimited. QDM would relish the opportunity to introduce this system into other agencies to help them realize the benefits of improved communication, teamwork, and coordination that this workflow-enabled Groupware environment can provide.

Step 1: Obtain and Use the Software

The first step on the path to these benefits is to obtain and actively use the software. Tools such as this that enable an organization to improve processes are valuable, and investing in them is an investment in improving the ways that people work together. QDM has made this first step easy by providing, in **Quality *At Work***, a cost-effective point of entry into the market. Because the system is inexpensive, easy to use, and fully functional "out-of-the-box", the entire organization is able to begin using it immediately. The fact that the tools automate such pervasive processes as assigning action and soliciting input will enable the workflow technology to begin to subtly pervade the culture.

The most seamless way to introduce this technology to the culture is with tools that work in user's electronic Mail files. Most users are comfortable and experienced enough in the use of electronic mail to notice and appreciate the benefits that such tools as Action Items and Brainstorms add to the baseline electronic Mail functionality of Memo, Reply, and Phone Message. Once these benefits are achieved in the individual Mail files, the tools can be rolled out to public spaces such as Lotus Notes databases, so ad-hoc processes can be generated from the business context of the database. These processes, generated from databases but acted upon in Mail files, can integrate the notions of individual productivity and organizational goals. These tools and processes create an interconnected network of coordinated activity and team members.

Step 2: Observe and Analyze Patterns of Use: Extend System as Necessary

As the tools are used throughout an organization, the patterns that develop should be analyzed. If users are consistently using generic ad-hoc tools for a specific purpose, creating a customized version of the tool that is specific to that purpose should be considered. If users are consistently linking together the same types of ad-hoc tools, the possibility of linking these processes together in a production workflow system should be considered.

The design and use of the workflow toolbox lend themselves to the implementation of this plan. By analyzing patterns of use, management strategists and workflow technologists may add, delete, or refine the individual components of the toolbox as dictated by past usage. For example, if users frequently use a **Quality *At Work*** Action Item to request that marketing collateral be sent to new sales prospects, a custom "Send Materials" Action Item may quickly and easily be developed and incorporated into the toolbox. Because the tools are basic, the process of continually refining the toolbox to meet the needs of the users is easy. The flexibility of the tools and system will ensure their applicability even as individuals, workgroups, and the entire organization rise to meet the challenges of the future.

The workflow toolbox approach effectively clears the cultural hurdle to workflow because the improvements are achieved through evolutionary, not revolutionary, change and are achieved in a manner that is consistent with the culture of the organization. By enabling people to apply the tools to their existing methods of getting the job done, the toolbox approach tailors the technology to fit the work habits of the users rather than forcing users to pattern their work habits after the technology.

Recommendation: Provide Phase III Funding

The success of our technologies and methodologies in both the pilot environment and the business world as a whole demonstrate the power and relevance of the fruits of QDM's Phase II SBIR effort. One year into the Phase II effort, we released the commercial software product, **Quality *At Work,*** which is now installed in companies of all sizes worldwide. The SBIR funds invested in QDM have resulted in a "Total Product" delivery mechanism that skillfully combines the power of the technology with the ability to maximize its benefits within an organization.

These successes also evince the significant Phase III potential of this effort. QDM can build on this solid foundation of success and continue both technological and methodological progress. Indeed, QDM has been running its own independently funded Phase III effort in parallel with our SBIR Phase II efforts. During these commercial efforts, QDM has used more than $1,000,000 in funds for Research & Development, has cooperated with Lotus from the earliest beginnings of Lotus Notes, and has established and is maintaining distribution channels domestically and worldwide.

Despite this success, many extraordinary opportunities remain. The full potential of these technologies and theories has not been realized. With Phase III funding, the benefits from this SBIR investment could be extended and successes could continue. Enhancements to both the Workflow and GUI modules of the Phase II prototype would create a compelling groupware application that would be completely unique in the current market. Nowhere is there a groupware technology that so tightly integrates workflow functionality with Graphical User Interface technologies for direct use by end-users.

The broad spectrum of applicability of our workflow module has been demonstrated both within our SBIR pilot environment and in the global commercial software marketplace. Enhancements to this module, in concert with a generalized, easy-to-use Graphical User Interface that reads and displays workflow data, would build on the successes of the Phase II research.

Recommendation: Generate New Phase I Solicitations

The success of this Phase II effort and the results of our research during it have opened up new possibilities for Phase I SBIR solicitations. For example, Government Agency-specific GUIs could be created that could give management real-time "Control Panel" views of the processes specific to their organizations. In addition to agency-specific possibilities, universally applicable object-oriented technologies such as those found in the Workflow and GUI modules of this effort continue to explode with possibility. The speed with which the software industry is moving is opening up new opportunities for integrating technology into real business situations. QDM, through its combination of technological savvy and methodological expertise, has proven an unparalleled ability to put technology to work.

A Request from Quality Decision Management

QDM is enthusiastic about the possibility of disseminating the benefits of workflow-enabled Groupware throughout the Government. Other agencies, at minimal additional investment, can and should be able to take advantage of the technology that was born of this SBIR effort. The benefits that these agencies would achieve would be a ringing endorsement and acknowledgment not just of this particular technology, but of the SBIR program as a whole, and of the foresight of our contract management and sponsor for supporting this effort.

To facilitate the dissemination of these benefits throughout the Government, QDM would like to request a Point of Contact with whom we can maintain relations and through whom we might introduce this system to other Government agencies. We feel that there is significant untapped opportunity for this technology to help other agencies and ask only for some assistance in introducing and providing it to them.

Quality Decision Management's Future Plans

Our goal is to dominate the niche we have created. The QDM concept of Management Technology is going to become increasingly prevalent in the software industry and the business world in general. When the rest of the software industry starts to realize the importance of the synergy between workgroup technologies and cultural issues, QDM will have been integrating the two concepts for years. We are currently at the head of the pack in this area and fully intend to stay there.

Obviously, the first step in this strategy for the future is to continue efforts in the commercial software arena. Work is currently being done on **Quality *At Work***, the product that grew out of the workflow module of the SBIR system. We are providing even more robust and flexible tools to our growing end-user community as well as the capability to "**Quality *At Work*-enable**" any existing business application in Lotus Notes.

This capability is consistent with our belief that technology should be integrated into the culture and practices of the organization, rather than forcing the culture to submit and conform to the technology. "**Quality *At Work*-enabling**" applications is the prime example of that type of integration; **Quality *At Work*** fits seamlessly over existing Lotus Notes applications, introducing the culture to workflow without revolutionizing the way the organization does business. As we have detailed throughout this report, seamless implementation of these technologies can provide wide-scale benefits to an organizations' communication, teamwork, and productivity.

QDM is thankful for the opportunity presented by the SBIR program to use our skills and innovation to help businesses worldwide achieve these gains. We see the opportunity to continue to do so through continued strong relations with both Government and corporate customers and alliances.

REFERENCES

Action Technologies, Inc. (1992). *Actionworkflow™ Application Development Guide.*

Opper, S. (1992). *Technology for teams: Enhancing Productivity in Networked Organizations.* New York: Van Nostrand Reinhold.

Marshak, R. (1993). What is productivity, anyway? *Patricia Seybold's Notes on Information Technology.* June 1993.

Bibliography

Akao, Y. (1990). *Quality Function Deployment.* Cambridge, MA: Productivity Press.

Brassard, M. (1989). *The Memory Jogger Plus+™.* Methuen, MA: GOAL/QPC.

DeJean, D., & DeJean, S.B. (1991). *Lotus Notes at Work.* New York, NY: Brady Publishing, a Division of Simon & Shuster.

Deming, W. E. (1986). *Out of the Crisis.* Cambridge, MA: Massachusetts Institute of Technology.

Dunham, R. (1991). *Business Design Technology:* Software Development for Customer Satisfaction. Twenty-Fourth Hawaii *International Conference on System Sciences.* Honolulu, HA: Institute of Electronics Engineers, Inc.

Flores, F., (1982). *Management and Communication in the Office of the Future.* Forthcoming.

(1991). GAO Report Examines Impact of TQM on Productivity, Profitability. *On Q,* 6(7).

Garvin, D. A. (1993). Building a Learning Organization. *Harvard Business Review,* Cambridge, MA, 4(7).

GOAL/QPC. *1989 Research Report Hoshin Planning: A Planning System for Implementing Total Quality Management (TQM).* Methuen, MA: GOAL/QPC, 1989.

IDC/Avante Technology. (1992). *Workflow Software Study,* Framingham, MA.

Jeffrey, R.A.K.., Rhodes, D. S., & Evens, A. L. (1990). *Quality Function Deployment: Management Integration For the Logistician.* North Andover, MA: Quality Decision Management, Inc.

Johansen, R.; Sibbet, D.; Benson, S.; Martin, A.; Mittman, R.; Saffo, P. (1991). *Leading Business Teams, How Teams Can Use Technology and Group Process Tools to Enhance Performance.* Reading, MA: Addison-Wesley Publishing Company, Inc.

Keen, P.G.W. (1991). *Shaping The Future, Business Design Through Information Technology.* Boston, MA: Harvard Business School Press.

King, B. (1989). *Hoshin Planning the Development Approach.* Methuen, MA: GOAL/QPC.

Mizuno, S., (Ed). (1988). *Management For Quality Improvement, The 7 New QC Tools.* Cambridge, MA: Productivity Press.

Moore, G. A.. (1992). *Crossing the Chasm - Marketing and Selling Technology Products to Mainstream Customers,* Harper Business.

Nevins, J. L., Whitney, D. E. (1989). *Concurrent Design of Products & Processes.* New York:: McGraw-Hill Inc.

BIBLIOGRAPHY (Continued)

Quality Decision Management, Inc. (1991a). *FACTS Communications Forum User's Guide.* North Andover, MA: Quality Decision Management, Inc.

Quality Decision Management, Inc. (1991b). *FACTS Automated Total Quality Management System Strategic Plan.* North Andover, MA: Quality Decision Management, Inc.

Quality Decision Management, Inc. (1991c). *Quality At Work® - Groupware for Quality Management Users Guide*, North Andover, MA: Quality Decision Management, Inc.

Quality Decision Management, Inc. (1991d). *Groupware System for Multidisciplinary Participation* Phase II Proposal Topic AF90-063, (F41624-91-C-5000). Wright-Patterson AFB, OH: Acquisition Logistics Branch of the Armstrong Laboratory Research Branch.

Quality Decision Management, Inc. (1992). *Groupware System for Multidisciplinary Participation Final Technical Report/Phase II Program Plan* (F41624-91-C-5000-P00002). Wright-Patterson AFB, OH: Acquisition Logistics Branch of the Armstrong Laboratory Research Branch and Wright-Patterson AFB, OH: Process Improvement of the Center for Support of Technology Insertion.

Quality Decision Management, Inc. (1993a). *Groupware System for Multidisciplinary Participation Front-End Module System Design Specification,* (F41624-92-C-5006, CDRL: A0004). Wright-Patterson AFB, OH: Acquisition Logistics Branch of the Armstrong Laboratory Research Branch.

Quality Decision Management, Inc. (1993b). *Groupware System for Multidisciplinary Participation Initial Prototype System Design Specification,* (F41624-92-C-5006, CDRL: A0004). Wright-Patterson AFB, OH: Acquisition Logistics Branch of the Armstrong Laboratory Research Branch.

Quality Decision Management, Inc. (1993c). *Quality At Work® - Workgroup Software for Customer-Centric Management - Users Guide.*

Quality Decision Management, Inc. (August 1992 - January 1994). *Groupware System for Multidisciplinary Participation* Monthly Status Reports, (F41624-92-C-5006, CDRL: A0004).

Marshak, D. (1992). The Notes Phenomenon, *Patricia Seybold's Notes on Information Technology.* December 1992.

Dyson, E. (1992). *Release 1.0, A Monthly Report By Esther Dyson.* 30 September 1992.

Scholtes, P.R. (1990). *The Team Handbook.* Madison, WI: Joiner Associates, Inc.

Schrage, M. (1990). *Shared Minds.* New York, NY: Random House, Inc.

Senge, Peter M. (1990). *The Fifth Discipline*, New York: Doubleday.

BIBLIOGRAPHY (Continued)

Slater, R. (1991). *Integrated Process Management: A Quality Model.* New York: McGraw-Hill, Inc.

Winograd, T. & Flores, F. (1990). *Understanding Computers and Cognition.* Reading, Massachusetts: Addison-Wesley Publishing Company, Inc.

Acronyms

ABB	Asea Brown Boveri
AF	Air Force
AL/HRGA	Acquisition Logistics Branch of the Armstrong Laboratory Logistics Research Branch
ASC/SMEF	Aeronautical Systems Command of the Engineering FACTS branch of the Subsystems System Program Office
ASC/SMT	Aeronautical Systems Center Technology Transition Division
API	Application Programming Interface
ATI	Action Technologies, Inc.
BTS	Business Tracking System
CE	Concurrent Engineering
CSTI	Center for Support of Technology Insertion
DDE	Dynamic Data Exchange
DLA	Defense Logistics Agency
DoD	Department of Defense
FACTS	Fasteners, Actuators, Connectors, Tools, and Subsystems
FY	Fiscal Year
GSA	General Services Administration
GUI	Graphical User Interface
HQ AFMC	Headquarters Air Force Materiel Command (HQ AFMC)
IDC	International Data Corporation
IFTF	Institute for the Future
IPD	Integrated Product Development
MP	Management and Planning Tools
OLE	Object Linking and Embedding

Acronyms (Continued)

PC	Personal Computer
PI	Process Improvement
PIBO	Process Improvement Business Opportunities Division
POC	Point of Contact
PMR	Program Monthly Review
PRAM	Productivity, Reliability, Availability, and Maintainability Program
QAW	Quality *At Work*
QC	Quality Control
QDM	Quality Decision Management, Inc.
QFD	Quality Function Deployment
RAMTIP	Reliability and Maintainability Technology Insertion Program
SAB	Scientific Advisory Board
SBIR	Small Business Innovation Research
SM	Subsystems System Program Office
SMGF	FACTS Project Office
SPC	Statistical Process Control
SPO	System Program Office
TQM	Total Quality Management
TTO	Technology Transition Office
UI	User Interface
WMS	Workflow Management Server
WPAFB	Wright-Patterson Air Force Base
WYSIWYG	What You See Is What You Get

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